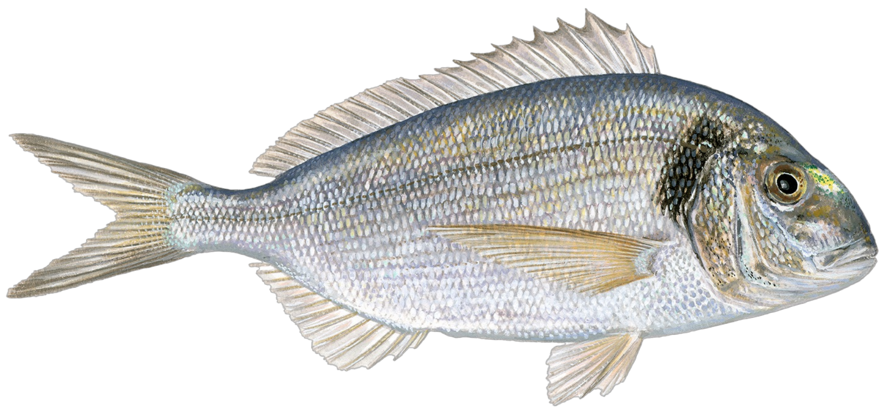
Environmental sustainability assessment of farmed European seabass, Gilthead bream, and Meagre from the European Union produced in marine net pens, semi-intensive ponds, and semi-extensive ponds



Species:	European seabass (*Dicentrarchus labrax*), Gilthead bream (*Sparus aurata*), Meagre (*Argyrosomus regius*)
Location:	European Union: (Croatia, Cyprus, France, Greece, Italy, Malta, Portugal, Slovenia, Spain, Turkey, Egypt)
Gear:	Marine net pen, Semi-intensive pond, Semi-extensive pond
Type:	Farmed
Author:	Seafood Watch
Published:	July 6, 2020
Report ID:	645

Assessed using Seafood Watch Aquaculture Standard v3.1

About Seafood Watch®

Monterey Bay Aquarium's Seafood Watch program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Watch Assessment. Each assessment synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." This ethic is operationalized in the Seafood Watch standards, available on our website here. In producing the assessments, Seafood Watch seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying assessments will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Watch assessments in any way they find useful.

Guiding Principles

Seafood Watch defines sustainable seafood as originating from sources, whether fished[1] or farmed that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following guiding principles illustrate the qualities that aquaculture farms must possess to be considered sustainable by the Seafood Watch program. Sustainable aquaculture farms and collective industries, by design, management and/or regulation, address the impacts of individual farms and the cumulative impacts of multiple farms at the local or regional scale by:

1. **Having robust and up-to-date information on production practices and their impacts available for analysis;**
   Poor data quality or availability limits the ability to understand and assess the environmental impacts of aquaculture production and subsequently for seafood purchasers to make informed choices. Robust and up-to-date information on production practices and their impacts should be available for analysis.
2. **Not allowing effluent discharges to exceed, or contribute to exceeding, the carrying capacity of receiving waters at the local or regional level;**
   Aquaculture farms minimize or avoid the production and discharge of wastes at the farm level in combination with an effective management or regulatory system to control the location, scale and cumulative impacts of the industry's waste discharges.
3. **Being located at sites, scales and intensities that maintain the functionality of ecologically valuable habitats;**
   The siting of aquaculture farms does not result in the loss of critical ecosystem services at the local, regional, or ecosystem level.
4. **Limiting the type, frequency of use, total use, or discharge of chemicals to levels representing a low risk of impact to non-target organisms;**
   Aquaculture farms avoid the discharge of chemicals toxic to aquatic life or limit the type, frequency or total volume of use to ensure a low risk of impact to non-target organisms.
5. **Sourcing sustainable feed ingredients and converting them efficiently with net edible nutrition gains;**
   Producing feeds and their constituent ingredients has complex global ecological impacts, and the efficiency of conversion can result in net food gains or dramatic net losses of nutrients. Aquaculture operations source only sustainable feed ingredients or those of low value for human consumption (e.g. by-products of other food production) and convert them efficiently and responsibly.
6. **Preventing population-level impacts to wild species or other ecosystem-level impacts from farm escapes;**

1 "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates.

Aquaculture farms, by limiting escapes or the nature of escapees, prevent competition, reductions in genetic fitness, predation, habitat damage, spawning disruption, and other impacts on wild fish and ecosystems that may result from the escape of native, non-native and/or genetically distinct farmed species.

7. **Preventing population-level impacts to wild species through the amplification and retransmission, or increased virulence of pathogens or parasites;**
   Aquaculture farms pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites, or the increased virulence of naturally occurring pathogens.
8. **Using eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture;**
   Aquaculture farms use eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture, or where farm-raised broodstocks are not yet available, ensure that the harvest of wild broodstock does not have population-level impacts on affected species. Wild-caught juveniles may be used from passive inflow, or natural settlement.
9. **Preventing population-level impacts to predators or other species of wildlife attracted to farm sites;**
   Aquaculture operations use non-lethal exclusion devices or deterrents, prevent accidental mortality of wildlife, and use lethal control only as a last resort, thereby ensuring any mortalities do not have population-level impacts on affected species.
10. **Avoiding the potential for the accidental introduction of secondary species or pathogens resulting from the shipment of animals;**
    Aquaculture farms avoid the international or trans-waterbody movements of live animals or ensure that either the source or destination of movements is biosecure in order to avoid the introduction of unintended pathogens, parasites and invasive species to the natural environment.

Once a score and rating has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ratings and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide:

Best Choices/Green: Are well managed and caught or farmed in environmentally friendly ways.

Good Alternatives/Yellow: Buy but be aware there are concerns with how they're caught or farmed.

Avoid/Red: Take a pass on these. These items are overfished or caught or farmed in ways that harm other marine life or the environment.

Final Seafood Recommendations

Gilthead seabream (*Sparus aurata*) produced in marine net pens in the EU

Criterion	Score	Rank	Critical?
C1 Data	7.50	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	5.21	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**30.97**		
Final score (0-10)	**4.42**		

OVERALL RANKING

Final Score	4.42
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK

RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Gilthead seabream farmed in the EU

The score for gilthead seabream produced in marine net pens in the EU is 4.42 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

European seabass (*Dicentrarchus labrax*) produced in marine net pens in the EU

Criterion	Score	Rank	Critical?
C1 Data	7.50	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	5.38	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**31.15**		
Final score (0-10)	**4.45**		

OVERALL RANKING

Final Score	4.45
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK

RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: European seabass farmed in marine net pens in the EU

The score for European seabass produced in marine net pens in the EU is 4.45 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

Meagre (*Argyrosomus regius*) produced in marine net pens in the EU

Criterion	Score	Rank	Critical?
C1 Data	7.50	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	4.28	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**30.05**		
Final score (0-10)	**4.29**		

OVERALL RANKING

Final Score	4.29
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Meagre farmed in marine net pens in the EU

The score for meagre produced in marine net pens in the EU is 4.29 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

Gilthead seabream (*Sparus aurata*) produced in marine net pens in Turkey

Criterion	Score	Rank	Critical?
C1 Data	7.27	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	1.00	RED	NO
C5 Feed	5.21	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**28.75**		
Final score (0-10)	**4.11**		

OVERALL RANKING

Final Score	4.11
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Gilthead seabream farmed in Turkey

The score for gilthead seabream produced in marine net pens in Turkey is 4.11 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

European seabass (*Dicentrarchus labrax*) produced in marine net pens in Turkey

Criterion	Score	Rank	Critical?
C1 Data	7.27	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	1.00	RED	NO
C5 Feed	5.38	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**28.92**		
Final score (0-10)	**4.13**		

OVERALL RANKING

Final Score	4.13
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK

RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: European seabass farmed in marine net pens in Turkey

The score for European seabass produced in marine net pens in Turkey is 4.13 with two Red-ranked criterion for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

Meagre (*Argyrosomus regius*) produced in marine net pens in Turkey

Criterion	Score	Rank	Critical?
C1 Data	7.27	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	1.00	RED	NO
C5 Feed	4.28	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**27.82**		
Final score (0-10)	**3.97**		

OVERALL RANKING

Final Score	3.97
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Meagre farmed in marine net pens in Turkey

The score for meagre produced in marine net pens in Turkey is 3.97 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

Gilthead seabream (*Sparus aurata*) produced in semi-intensive ponds and lagoons in Egypt

Criterion	Score	Rank	Critical?
C1 Data	3.64	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	2.67	RED	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	5.21	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	2.00	RED	NO
C8X Source	-8.00	RED	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**4.51**		
Final score (0-10)	**0.64**		

OVERALL RANKING

Final Score	0.64
Initial rank	RED
Red criteria	5
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Gilthead seabream farmed in Egypt

The score for gilthead seabream farmed in brackish ponds and lagoons in Egypt is 0.64. With five Red-ranked criteria (Effluent, Habitat, Chemical Use, Disease, Source of Stock), one of which is Critical (Effluent), the final ranking is Red and a recommendation of Avoid.

European seabass (*Dicentrarchus labrax*) produced in semi-intensive ponds and lagoons in Egypt

Criterion	Score	Rank	Critical?
C1 Data	3.64	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	2.67	RED	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	5.38	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	2.00	RED	NO
C8X Source	-8.00	RED	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**4.69**		
Final score (0-10)	**0.67**		

OVERALL RANKING

Final Score	0.67
Initial rank	RED
Red criteria	5
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: European seabass farmed in Egypt

The score for European seabass farmed in brackish ponds and lagoons in Egypt is 0.67. With five Red-ranked criteria (Effluent, Habitat, Chemical Use, Disease, Source of Stock), one of which is Critical (Effluent), the final ranking is Red and a recommendation of Avoid.

Meagre (*Argyrosomus regius*) produced in semi-intensive ponds and lagoons in Egypt using commercial diets

Criterion	Score	Rank	Critical?
C1 Data	3.64	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	2.67	RED	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	4.28	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	2.00	RED	NO
C8X Source	-8.00	RED	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**3.59**		
Final score (0-10)	**0.51**		

OVERALL RANKING

Final Score	0.51
Initial rank	RED
Red criteria	5
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Meagre farmed in Egypt using commercial diets

The score for meagre farmed in brackish ponds and lagoons in Egypt using commercial diets is 0.51. With five Red-ranked criteria (Effluent, Habitat, Chemical Use, Disease, Source of Stock), one of which is Critical (Effluent), the final ranking is Red and a recommendation of Avoid.

Meagre (*Argyrosomus regius*) produced in semi-extensive ponds and lagoons in Egypt using whole fish

Criterion	Score	Rank	Critical?
C1 Data	3.64	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	2.67	RED	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	0.00	CRITICAL	YES
C6 Escapes	5.00	YELLOW	NO
C7 Disease	2.00	RED	NO
C8X Source	-8.00	RED	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**-0.70**		
Final score (0-10)	**-0.10**		

OVERALL RANKING

Final Score	-0.10
Initial rank	RED
Red criteria	6
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Meagre farmed in Egypt using whole fish

The score for meagre farmed in brackish ponds and lagoons in Egypt using whole fish, is -0.10. With six Red-ranked criteria (Effluent, Habitat, Chemical Use, Feed, Disease, Source of Stock), two of which are Critical (Effluent, Feed), the final ranking is Red and a recommendation of Avoid.

Executive Summary

This report focuses on the production practices used to culture gilthead seabream, European seabass and meagre in the European Union (EU), Turkey and Egypt. This geographic scope incorporates over 93% of the total combined global production of these three species. Globally, production volumes of cultured gilthead seabream and European seabass are approximately the same, whereas production of meagre, a relative newcomer to aquaculture, is much less.

In 2017, just over 218,000 MT of gilthead seabream were farmed and almost 216,000 MT of European seabass; by comparison, production of meagre amounted to nearly 32,000 MT. Taken together, the combined, cultured output of these species that was reported to FAO for 2017 was slightly less than 466,000 MT: 47% gilthead seabream, 46% European seabass, and 7% meagre. Furthermore, based on FAO 2017 data, four countries produce over 84% of the production under consideration in this report: Turkey (35%), Greece (22%), Egypt (20%) and Spain (8%). Production in the EU and Turkey typically takes place in sea cages, whereas in Egypt earthen ponds and lagoons are utilized.

Although US trade data does not distinguish farmed produce from wild or offer complete granularity of seafood imports at the species level, it can be extrapolated that in 2018, the US' combined volume of seabream and seabass imports, from countries that culture gilthead seabream and European seabass, was around 8,282 MT. Of this quantity, 7% was seabream and 93% was seabass. Turkey and Greece are by far the largest exporters of these products followed by Spain then Cyprus. Importation data concerning meagre could not be determined as this species is not specifically defined in trade statistics. Although Egypt is a major producer, and its production of these species is rapidly increasing, the country's aquaculture output is largely retained for domestic consumption.

This Seafood Watch assessment involves a number of different criteria covering impacts associated with: effluent, habitats, wildlife and predator interactions, chemical use, feed production, escapes, introduction of non-native organisms (other than the farmed species), disease, the source stock, and general data availability. Due to the similarity of production methods used to farm gilthead seabream, European seabass and meagre, such that they are often cultured together in the same facility, albeit in separate enclosures, all three species are considered in tandem for each criterion.

Due to significant regional differences, in both production systems and legislative framework, Egypt has been assessed separately from the European Union and Turkey for many of the ensuing criteria. Although the production systems and methods used in the European Union and Turkey are easily comparable to one another, and pose similar ecological concerns, the governance in place in either jurisdiction is clearly distinct and is not always comparable; these differences are explored and commented upon throughout the following report, and scoring outcomes differentiated where appropriate. A review of the various feed metrics relevant to each of the three different species under consideration also demonstrated that separate scores were warranted for each. This report, therefore, has resulted in ten separate recommendations that take species divergence and regional differences into consideration.

Data quality and availability

Overall, there is an abundance of data available on the seabass, seabream and meagre sector in the EU and Turkey. Over the last few decades, as the industry has expanded throughout this region, the sector has benefited greatly from both European Commission-funded and industry-funded research efforts. This is testimony both to the economic importance of this sector and a growing awareness that environmental impacts need to be better understood for the industry to move forward. In addition to the prodigious volume of peer-reviewed, published literature that these endeavors have resulted in, there are also a great deal of collated government statistics available from across the region. Of note, significant differences were identified in the quality and availability of data pertaining to Criterion 4 – Chemical Use, thus the scores for the EU and Turkey were differentiated in this regard. The final numerical score for Criterion 1: EU – Data is 7.5 out of 10, whereas for Criterion 1: Turkey – Data it is 7.3 out of 10.

In contrast to the EU and Turkish sector, the availability of data pertaining to production of these species in Egypt is much less. Much of the data that is available comes from initiatives funded by international organizations such as FAO, WorldFish and CGIAR. According to FAO statistics, significant Egyptian production of these species only commenced around 2010, hence there has been limited time for literature on this sector to amass. Of additional note, only a few percent of Egyptian production are comprised of these species – a factor which partially elucidates the sparsity of data available. Notably, data concerning the sector's use of chemicals was not identified in literature and minimal information pertaining to management of the industry or effluent and habitat impacts were forthcoming. While feed data from commercial suppliers was easily obtained, it is hard to ascertain from the data available the extent to which commercial diets are implemented by the sector. Likewise, data pertaining to the source of stock criterion were sparse and data on predator interactions were not identified. Overall, the final numerical score for this category, Criterion 1: Egypt – Data, is 3.6 out of 10.

Effluent

Recent scientific review pertaining to the impact of effluents arising from farms culturing gilthead seabream, European seabass and meagre in the EU and Turkey concur that such farms do not generally cause nutrient enrichment that is detectable beyond ~100 meters of the cage field. Modern feeding practices, which utilize commercially formulated diets and feed monitoring equipment to minimize waste, have done much to diminish nutrient loading. The specific characteristics of each farm site play a major role in determining what the extent and severity of effluent impacts may be within each location, and some environments inevitably exhibit a greater degree of sensitivity than others. Effective site selection greatly reduces the potential for fish farm effluents to create negative impacts within the receiving waterbody, a concept which is widely implemented in the Mediterranean basin through use of allocated zones for aquaculture (AZA). In this regard, studies of seabream and seabass farms in Turkey and Greece have documented minimal negative trophic impacts occurring due to nutrients being released into the water column as a result of farming activity, and this is attributed to the highly efficient nutrient dynamics that exist between different tropic levels in such oligotrophic environments. Despite this, literature indicates occasional impacts to the benthic environment and sensitive seagrass beds have and do occur beyond the allowable zone of effect (AZE). To address this, both the EU and Turkey have enacted legislation that prohibits farming activities in the vicinity of sensitive habitats, thus in recent years farms have relocated further offshore, beyond the typical depth range of *P. oceanica* meadows. In Greek law, it is a prerequisite that farms must be sited away from seagrass meadows and in deeper water if they want to obtain permits for expansion, which in effect has moved the industry further off-shore. The situation is similar in Turkey: over a decade ago, legislation was passed which compelled farms to relocate into deeper water sites of 30 m depth or greater. However, at the regional level and over large marine areas, the potential cumulative impacts arising from dissolved nutrient dispersal and assimilation are poorly understood, highlighting the need for careful monitoring of industry expansion. The final numerical score for Criterion 2: EU & Turkey – Effluent – is 5 out of 10.

In Egypt, no specific studies on the effluent impacts of typical fish farms were identified, therefore the Risk-based assessment was used. This was assessed by analyzing two aspects of effluent impact: firstly, the biological wastes discharged by farms, based on average FCRs and protein content of feed, secondly, the content and enforcement of management measures. In the first instance, it was estimated that biological waste discharges from fish farms in Egypt are high; in the second instance, both the content and enforcement of management measures to mitigate the impact of fish farm effluents on the environment are lacking. The final numerical score for Criterion 2: Egypt – Effluent – is 0 out of 10 indicating that waste discharge is high and regulatory control and management is weak; this is considered a Critical conservation concern to Seafood Watch.

Habitat

Studies on seabream, seabass and meagre aquaculture taking place in the EU and Turkey demonstrate that the sector has moderate habitat impacts within the immediate footprint of the farm. Two of the most vulnerable habitats present in the water bodies included in the scope are *Posidonia* seagrass meadows and maërl beds and studies reviewing the impact of fish farming activities upon these habitats date back to the 1990s. In 1992 the EU Habitats Directive was enacted to protect these and other identified priority habitats. Subsequently, member states have introduced legislation at the national level to implement the requirements of this directive. In alignment with this EU initiative, Turkey also introduced regulations to ensure farms were not located above these sensitive habitats, in 2006; similar legislation was also passed shortly thereafter in Greece, in 2009. The effectiveness of robust regulation is somewhat limited by moderate enforcement, given the varying levels of capacity and adoption of key environmental indicators, EU Directives, and GFCM resolutions across the sector, resulting in a moderate impact score of 6 out of 10 for Criterion 3: EU & Turkey – Habitat.

There is a lack of data available concerning the habitat impacts of seabass, seabream and meagre production in Egypt, which necessitates a precautionary approach in the scoring of this Criterion. Habitats contiguous to fish farms are clearly adversely affected by anthropogenic impacts, although the primary polluter would appear to be the dominant agriculture sector.

There is a scarcity of both freshwater and arable land in Egypt, which means that land is only approved for aquaculture if it is not suitable for agricultural production. Although the importance of environmental management is recognized and broadly addressed in legislation, it is poorly implemented and laws specifically pertaining to aquaculture and the species under assessment are hard to identify. Specific monitoring requirements for aquaculture are lacking. EIAs are theoretically required for some types of aquaculture although this is reportedly seldom enforced. The final numerical score for Criterion 3: Egypt – Habitat - is 3 out of 10.

Chemical Use

Due to the regional differences highlighted in this production parameter review on chemical use, three separate scores have been assessed: one for the EU, one for Turkey, and one for Egypt.

In general, the regulatory framework that is in place to govern drug use by the aquaculture sector in the EU and Turkey would appear to be somewhat effective in limiting the use of antibiotics due to the requirement for veterinary prescriptions, though chemicals that are highly and critically important to human medicine are approved for use in both jurisdictions. Although some evidence of resistance to antibiotic treatments have been documented in studies of Mediterranean farmed seabass and seabream, these studies do not attribute this situation to misuse of antibiotics by the aquaculture sector, per se, but note that there are an array of contributory anthropogenic factors. In recent years it has become mandatory in most EU member states to report the quantities and types of antibiotics used in food-animal production to the centralized European Medicines Agency and, in Turkey, veterinarians must make their prescription records available for inspection when requested. New EU legislation has also mandated that farm-level details of antibiotic use must be reported, with a phase-in period commencing in 2022 – although data concerning sector-specific usage is not publicly available at the present time in either the EU or Turkey. Communications with veterinary professionals within the sector, both in the EU and Turkey, suggest that antibiotic use in the sector has reduced significantly in recent years, commensurate with the increased availability and routine application of effective vaccines by seabass, seabream and meager farmers, with close to 100% of stocks reportedly being vaccinated against several bacterial diseases. Antibiotic use data for fish are available in the EU, but not disaggregated at the species level, thus specific usage data for the seabass, seabream and meagre sector are unknown. While communication with some industry veterinarians have indicated that antibiotics are typically used less than once per cycle, additional information suggests that antibiotic use is common in Greece (>50% of total EU production), with no quantification of treatment frequency beyond a minority of the industry exceeding 3 treatments per cycle. Further information indicates that critically-important antimicrobials for human medicine were used in 6% of all antibiotic treatments in Greece in 2019 (a decrease from 30% in 2017), though again, total volume and number of treatments are unknown. No such quantifications of antibiotic use in Turkey could be ascertained.

Overall, despite increased vaccinations and indications from veterinary professionals that antibiotics are typically used less than once per production cycle, additional data indicate that the use of antibiotics in Greece, the major EU producer country, is common and at times, frequent (>3 treatments per cycle). Given the available data and uncertainty in treatment frequency, it is considered that highly important antimicrobials are being used in unknown quantities in the EU, and critically important antimicrobials are being used in unknown quantities in Turkey. In addition, parasiticides such as formalin are in use in both sectors, with no indication of the treatment volumes or frequency able to be ascertained. Net pens are an inherently open production system that allow the discharge of active chemicals, and therefore, an intermediate score is warranted for each sector. The difference in the scores between the EU and Turkey are driven by the unknown usage patterns of different antimicrobials, greater data availability in the EU, as well as more stringent regulatory control in the EU. The final score for Criterion 4 – Chemicals: EU is 3 out of 10, whereas the final score for Criterion 4 – Chemicals: Turkey is 1 out of 10.

Data on the Egyptian sector suggests that there is a lack of regulatory control concerning chemical use by producers of the species under consideration and this necessitates that a precautionary approach is used to score this Criterion. This method of evaluation is further supported by data which demonstrates the development of antibiotic resistant pathogens within the aquaculture sector at large; this includes the usage of chemicals which are critically important to human health, which appear to be being used in unknown quantities. The final score for Criterion 4 – Chemicals in Egypt is 0 out of 10.

Feed

Data to inform this Criterion has been sourced directly from the main commercial aquafeed suppliers to fish farms in both Egypt and the Mediterranean region. The economic FCRs used to score this Criterion are 2.3 for seabass, 2.0 for seabream and 1.7 for meagre. In addition, it is evident that production of meagre in Egypt is commonly fed whole fish, rather than commercial diets, and in such instances an eFCR of 9 has been used. In light of this, two separate ratings have been calculated for the Egyptian meagre sector.

With the exception of meagre produced in Egypt using whole fish, the FFER for seabass, seabream and meagre is 0.87, 1.24 and 1.47, respectively. Since the source fisheries used in all diets are the same, all three species score -6 out of -10 for Factor 5.1b. When added together, these scores result in a final Factor 5.1 score of 6.77 out of 10 for seabass, 5.41 out of 10 for seabream, and 4.57 out of 10 for meagre. Since most fish produced across the scope of this assessment are consumed in domestic markets, where fish are most frequently served whole, this has been factored into the calculations for Factor 5.2, and the resultant net protein gain/loss values for seabass, seabream and meagre are -52.41%, -49.71%, -46.42%, respectively, indicating a net loss of protein. The subsequent final Factor 5.2 score for seabass is 4 out of 10, whereas seabream and meagre both obtain a score of 5 out of 10. The total global land and ocean area appropriated per MT of farmed fish for seabass, seabream and meagre is 16.32 hectares, 14.71 hectares and 18.58 hectares, respectively, resulting in scores of 4, 5, and 3 for Factor 5.3. When the scores for all three Factors are combined, the final Criterion 5 – Feed score for seabass is 5.38 out of 10, for seabream it is 5.21 out of 10, and for meagre it is 4.28 out of 10.

In consideration of farmed meagre produced in Egypt on a diet of whole fish, the FFER is calculated to be 9, due to an eFCR of 9. Since the whole fish used as feed come from unknown source fisheries, this warrants a score of -10 out of -10 for Factor 5.1b; when these scores are combined, the final Factor 5.1 wild fish use score is zero out of 10. The Factor 5.2 score, which assesses net protein gain or loss, is 1 out of 10, due to a -87.59% net loss of protein. In consideration of the diet used, the ocean area appropriated per each MT of farmed meagre produced is calculated to be 64.37 hectares, resulting in a Factor 5.3 score of zero out of 10. The final Criterion 5 – Feed score for meagre farmed in Egypt using whole fish is therefore zero out of 10, which is a Critical conservation concern to Seafood Watch.

Escapes

With regard to the EU and Turkey, given the available data and the high escape risk that is inherent with open-net pen aquaculture systems, it is clear that multiple large escapes and frequent trickle losses have occurred, and continue to occur, particularly in the seabream sector, and any corrective actions have not been adequate to limit escapes. This warrants a score of 0 out of 10 for Factor 6.1. However, the implementation of published best management practices is assumed to occur to some degree, and some areas have begun implementing mandatory escape prevention practices. This then partially warrants a score of 2 out of 10, and a final intermediate score of 1 out of 10 for Factor 6.1 is given for the EU and Turkey.

While seabass and seabream are considered native throughout the geographic range encompassed by this report, this is not entirely the case for meagre, which is evidently rare or absent in the more northerly regions under consideration. In all jurisdictions, there are concerns that domesticated escapees could cause genetic drift to occur in wild populations should breeding take place between farmed and wild individuals. The ecological threat that this presents has attracted the attention of numerous research projects and much funding has been directed toward understanding the causative factors of such events and their ecological impacts, plus the development of measures to mitigate against these threats. Escape through spawning, whereby viable fertilized eggs emanate from cages, is also feasible, although this is reportedly rare and is typically only associated with cultured seabream, not with seabass or meagre. Selective breeding in aquaculture, which favors traits such as fast growth, appealing morphology and disease resistance, inevitably results in loss of genetic diversity within farmed stocks. Studies show that phenotypic variation exists between wild and farmed seabass, seabream and meagre, and also indicate that some genetic introgression has occurred, resulting in a score of 3 out of 10 for Factor 6.2 Competitive and Genetic Interactions: EU & Turkey. When the scores for these two factors are combined, the final score assessed for Criterion 6: Escapes - EU & Turkey is 2 out of 10.

In Egypt, culture of seabass, seabream and meagre primarily occurs in earthen ponds, which are located between +3 and -1 meters above sea level. Although limited data on aquaculture escapes were identified, it is evident that winter storms and floods are increasingly common in the region and these weather conditions inevitably facilitate escape events from ponds located in this flood prone area. Factor 6.1 Escape Risk: Egypt scores 0 out of 10. However, since juveniles are typically wild-sourced from local fisheries, escaped individuals pose a low concern in terms of competitive and genetic interactions with wild conspecifics and this results in a score of 9 out of 10 for Factor 6.2 Invasiveness: Egypt. When these factors are combined, the final numerical score for Criterion 6: Escapes – Egypt is 5 out of 10.

Disease, pathogen and parasite interaction

While there is relatively sparse documentation of disease transmission occurring between wild and farmed fish within the EU and Turkey, it appears likely that a dynamic and perpetual circulation of pathogens and parasites is ongoing, since net pen systems are open to their surroundings and consistently exchanging water with the surrounding environment. A review of literature on the sector indicates that both policy makers and farmers have greatly increased their awareness of disease issues in recent years, although it is hard to quantify the degree to which biosecurity measures (e.g. disinfection of equipment, use of certified disease-free fry, etc.) intended to stem the transmission of disease are implemented. Vaccination, which is recognized as one of the most efficient forms of disease prevention, is now a routine procedure on the majority of farms; this has undoubtedly done much to mitigate the spread of pathogens. However, although significant mortality events are notifiable by law in either jurisdiction, it does not appear that routine monitoring and reporting of disease incidence and/or mortality is legally required by any regulatory body. Recent survey data indicates that the average disease-related mortality rate for seabass and seabream farmed in the EU and Turkey is around 10% of the total fish stocked post hatchery; the total mortality rate is 15 – 20%, indicating that 50% of mortalities are attributable to disease. It is clear that some disease-related mortalities occur on farms, and though there are a number of biosecurity protocols in place, their implementation varies. Given the openness of net pens, the production system is open to the introduction and discharge of pathogens and parasites. This results in a moderate score of 4 out of 10 for Criterion 7: Disease - EU & Turkey.

There is not a great deal of literature detailing diseases impacting mariculture in Egypt, yet it is evident that numerous bacterial and parasitic diseases hamper the sector and cause mortalities in these flow through pond systems, which are open to the environment. Data on viruses is notably absent and no studies were identified that address the potential of on-farm diseases to become amplified and retransmitted to local wild species sharing the same water body. In light of a deficiency of data to robustly inform this Criterion, and because disease control systems, regulations, and management measures largely do not exist - and where they do, their implementation and enforcement is unknown and/or ineffective - the potential ecological risk of the sector is assessed to be moderately high which results in a score of 2 out of 10 for Criterion 7: Disease – Egypt.

Source of stock – independence from wild fish stocks

As with many of the criteria considered in this report, there is a significant difference between the source of juveniles stocked by farmers in Egypt compared to those used in the EU and Turkey. For this reason, these sectors have been assessed independently for this Criterion. Traditionally, seabass, seabream and meagre were captured from the wild and subsequently grown out in captivity throughout their natural range. On-growing typically took place in managed lagoons and coastal ponds; initially, these water bodies were stocked by naturally migrating fry and later on they were stocked through the efforts of targeted wild-capture. In Europe, a decline in the abundance of wild juveniles was observed in the 1960s and subsequent legislation, plus investment in research and hatcheries, brought about an almost complete cessation of wild fry use by farmers. Nowadays, hatcheries in the EU and Turkey produce ample fingerlings for the sector and this is primarily accomplished using domesticated broodstock. A similar downward trend in the abundance of wild marine fry has recently been observed in Egypt but, as yet, only limited quantities of hatchery-reared juveniles are available, and the industry is heavily reliant on wild-sourced fingerlings. These divergent sources of stock result in profoundly contrasting scores for either region: the final numerical score for Criterion 8X: Source of Stock – EU & Turkey is a deduction of 0 out of -10, which indicates that there is no environmental impact, whereas Egypt, due to its dependence on wild fry (>80% reliance on wild-stocks), has a deduction of -8 out of -10 for Criterion 8X: Source of Stock - Egypt.

Wildlife and predator mortalities

In conclusion, with regard to the EU and Turkey, although production of the species under consideration inevitably attracts predators, and interactions with wildlife do occur, data from the literature and personal communications indicate that any mortalities that may occur appear limited to exceptional cases. Even in the case of bottlenose dolphins, a Mediterranean subpopulation considered "Vulnerable" by the IUCN, data suggest that despite frequent interactions, entanglements and mortalities are rare. The final numerical score for Criterion 9X – Wildlife and Predator Mortalities is therefore -2 out of -10 for the EU and Turkey.

With regard to Egypt, it is again understood that the production of seabass, seabream, and meagre in ponds attracts wildlife and predators, primarily birds, amphibians, and reptiles. No information could be found with regard to any quantification of these interactions, nor the control methods (or lack thereof) employed by the industry, and information gleaned from literature regarding other pond production sectors in Egypt (tilapia, mullet), where lethal and non-lethal control methods are documented, was used as a proxy. In the absence of additional information, it is assumed that similar lethal and non-lethal control methods are in place in the seabass, seabream, and meagre sectors, and thus it is assumed that wildlife and predator mortalities do occur with unknown impacts to said wildlife species. The final score for Criterion 9X – Wildlife and Predator Mortalities is -6 out of -10 for Egypt.

Escape of secondary species

The production of seabass, seabream and meagre within the scope of this assessment is not considered to present a risk with regards to the unintentional trans-waterbody shipment of non-native species. Since no deduction is warranted, the assessed score for Criterion 10X – Escape of Secondary Species is 0 out of -10.

Final Recommendations

The final numerical scores for gilthead seabream, European seabass and meagre produced in marine net pens in the EU are 4.28, 4.31, and 4.15 out of 10, respectively. With two Red criteria

(Chemicals and Escapes), the overall, final ranking for all three species produced in the EU is Red and a recommendation of Avoid.

The final numerical scores for gilthead seabream, European seabass and meagre produced in marine net pens in Turkey are 3.96, 3.99, and 3.83 out of 10, respectively. With two Red criteria (Chemicals and Escapes), the overall, final ranking for all three species produced in Turkey is Red and a recommendation of Avoid.

The final numerical scores for gilthead seabream, European seabass, meagre fed commercial diets, and meagre fed whole fish produced in brackish ponds and lagoons in Egypt are 0.64, 0.67, 0.51, and -0.10 out of 10, respectively. With five Red criteria (Effluent, Habitat, Chemicals, Disease, and Source of Stock), and one Critical criterion (Effluent), the overall, final ranking for all three species produced in Egypt fed commercial diets is Red and a recommendation of Avoid. Meagre fed whole fish produced in Egypt has six Red criteria (Effluent, Habitat, Chemicals, Feed, Disease, and Source of Stock), with two Critical criteria (Effluent and Feed), and is rated Red with a recommendation of Avoid.

Table of Contents

About Seafood Watch® — *2*

Guiding Principles — *3*

Final Seafood Recommendations — *5*

Executive Summary — *15*

Table of Contents — *24*

Introduction — *25*

Scope of the analysis and ensuing recommendation — **25**

Species Overview — 25

Criterion 1: Data quality and availability — **39**

Criterion 2: Effluent — **49**

Criterion 3: Habitat — **71**

Criterion 4: Evidence or Risk of Chemical Use — **89**

Criterion 5: Feed — **106**

Factor 5.1 Wild Fish Use — 109

Factor 5.2 Net Protein Gain or Loss — 112

Factor 5.3. Feed Footprint — 114

Criterion 6: Escapes — **116**

Criterion 7: Disease; pathogen and parasite interactions — **130**

Criterion 8X: Source of Stock – independence from wild fisheries — **146**

Criterion 9X: Wildlife and predator mortalities — **153**

Criterion 10X: Escape of secondary species — **159**

Overall Recommendations — *161*

Acknowledgements — *171*

References — *172*

Appendix 1 - Data points and all scoring calculations — *221*

Introduction

Scope of the analysis and ensuing recommendation

Species:	**Gilthead Seabream**	(*Sparus aurata*)
	European Seabass	(*Dicentrarchus labrax*)
	Meagre	(*Argyrosomus regius*)

Geographic Region: **European Union, Turkey, and Egypt**

Figure 1: Overview of the major areas producing cultured seabream, seabass and meagre (Google Maps 2018)

Production Systems: Marine Net Pens in the European Union and Turkey
Brackish Ponds and Lagoons in Egypt

Species Overview

Brief Overview of Gilthead Seabream (*Sparus aurata*)

Gilthead seabream inhabit a wide geographic range, which spans from the Eastern Atlantic across the Mediterranean to the Black Sea (Studer 2018, Fishbase 2018b). It is a euryhaline species and therefore tolerant to a wide range of salinities, including brackish lagoons and hyper saline environments (Fishbase 2018b). Gilthead seabream are a member of the Sparidae family of fishes and the Latin name 'aurata' refers to the gold bar marking found between their eyes (Studer 2018, FAO 2018c). They commonly grow to a length of 35 cm (Fishbase 2018b), although an upper limit of 76 cm and a weight of 7.36 kg (IGFA 2018) has been documented.

The maximum age that has been recorded for this species is 11 years (FAO 2018c, Fishbase 2018b) to 12 years (Studer 2018). They frequent the surf zone, seagrass beds and sandy bottoms but they are also commonly found at depths of 30 m (Fishbase 2018b). Seabream are primarily carnivorous, and shellfish and crustaceans are a common part of their diet (Studer 2018, Fishbase 2018b). This species is a protandrous hermaphrodite; most individuals start life as males but become female at approximately three years of age (Gkagkavouzis et al. 2019, Studer 2018, Fishbase 2018b). Spawning occurs during October through December when water temperatures are between 16-20°C (Fishbase 2018b, Studer 2018).

Brief overview of European Seabass (*Dicentrarchus labrax*)

The extant range of the European seabass incorporates both the Mediterranean and Black Sea regions, plus an area of the northeastern Atlantic Ocean that spans from northern Norway down to Senegal (Fishbase 2018a, IUCN 2008). Interestingly, although the northeastern Atlantic and the Western Mediterranean are contiguous waterbodies, two distinct population groups have been identified in either region (Naciri et al. 1999). The European seabass is a member of the Moronidae family, which is comprised of the 'temperate basses' (Fishbase 2018a). While this species may venture down to depths of 100 m, it is more usually encountered in the littoral zone, along riverbanks, in shallow estuaries and in lagoons (FAO 2018c, Fishbase 2018a). It is a euryhaline, eurythermal, demersal species which is seasonally migratory; they travel inshore during summer and offshore during winter (FAO 2018c, Fishbase 2018a). Juvenile European seabass commonly feed on invertebrates and frequently move in schools, whereas adults tend to be more piscivorous and solitary (FAO 2018c, Fishbase 2018a). The maximum recorded size for European seabass is 103 cm and 10.13 kg (IGFA 2018) and they can live to around 30 years (IUCN 2008). Females reach sexual maturity later than males, at around 5-8 years (FAO 2018c, Fishbase 2018a). Males from the Atlantic stock start reproducing around 4-7 years old, whereas males in the Mediterranean group are already sexually mature at around age 2-4 (FAO 2018c, Fishbase 2018a). They are a pelagic spawner, with spawning events occurring in the open ocean between January and June when temperatures are above 9°C (Fishbase 2018a, IUCN 2008).

Brief Overview of Meagre (*Argyrosomus regius*)

Meagre is a coastal, semi-pelagic species (Haffray et al. 2012), which is widespread throughout the southern and eastern regions of the Mediterranean Sea; their range also extends eastward into the Aegean Sea, the Black Sea, and the Red Sea, the latter of which has been accessed in recent years via the Suez Canal (IUCN 2015). In northern Mediterranean counties, meagre is rare or absent in local fisheries statistics (Abou-shabana et al. 2012). Meagre also have a significant range in the Eastern Atlantic: from the southern regions of Norway, this fish is resident all the way down the western coast of Africa to Congo (IUCN 2015). Meagre belong to the Sciaenidae family, which are commonly referred to as drums, or croakers (Fishbase 2018c). This nomenclature was derived from the noise that males make with their swim bladder during mating season (FAO 2005c). Literature on this species variously report that males and females become sexually mature at around 2-3 years old (Abou-shabana et al. 2012) or, somewhat later, at 7 years old (Haffray et al. 2012). Meagre are demersal and exhibit anadromous migration; between April and July they return to estuaries to form large spawning aggregations (FAO 2005c, Fishbase 2018c). Although the range of this species is geographically large, only six spawning areas have thus far been identified, all of which are in coastal and estuarine regions. Four of these spawning areas are located in the North Atlantic, one of which is situated beside the large mud flats of Mauritania's Lévrier Bay and Banc d'Arguin, while the others in this locality are found at the mouths of three European rivers: the Gironde (France), the Tagus (Portugal), and the Guadalquivir (Spain). Another spawning ground is located off Egypt, where the the Nile delta meets the Mediterranean. In addition to these five spawning areas, one more aggregation site has recently been identified in the Aegean Sea, at the mouth of the Menderes river delta in Turkey (Haffray et al. 2012). Once they have completed the nursery phase, juveniles subsequently migrate along the coast or move offshore in late summer (IUCN 2015). Water temperatures dictate the migration patterns of this species: 17-21°C is the optimal window for growth (and also spawning), although 14-23°C is within the acceptable range (FAO 2005c). With an upper age limit of around 20 years (Abou-shabana et al. 2012), meagre can grow to over 50 kg and reach a length of 2 m (FAO 2005c). Meagre sub-adults rely mainly on a diet of fish and crustaceans while adults additionally prey on pelagic fish and cephalopods (FAO 2005c, Fishbase 2018c). Schools of meagre frequent shipwrecks and are often found near rocks in water depths of 15-100m (FAO 2005c).

Industry Statistics Overview
As can be noted in Figure 2, global production volumes of farmed gilthead seabream and European seabass are approximately the same, whereas production of meagre, which is a relative newcomer to aquaculture, is much less. Taken together, in 2017, the combined live weight production volume of these three species was nearly 466,000 MT (FAO 2019).

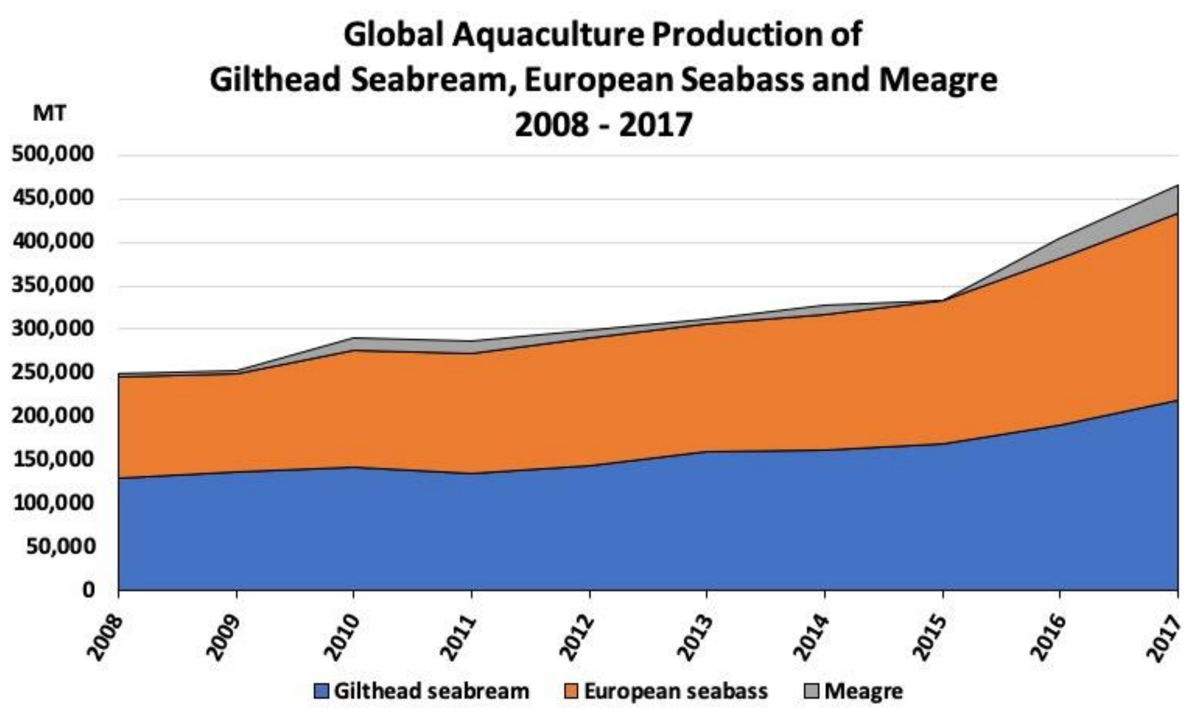


Figure 2: Global production volume comparison of cultured gilthead seabream, European seabass and meagre (FAO 2019)

Gilthead Seabream

Farmed production of gilthead seabream was first reported to FAO in 1970 by Italy, followed by Portugal in 1979 and Tunisia in 1982; these early production volumes were all very small. By 2017, total global cultured production of gilthead seabream reached 218,099 MT. A steady increase in global production of this species has occurred over the last decade, as is evident in Figure 3. It should be noted that Turkey's production is displayed at the bottom of each year's data column because Turkey has been the largest volume producer of this species in recent years, although prior to 2015 Greece was the globally dominant producer. The scope of this report incorporates almost 88% of the total global aquaculture production of gilthead seabream (much of the balance that is outside the scope of this report comes from Tunisia, which accounted for nearly 8% of global production in 2017).

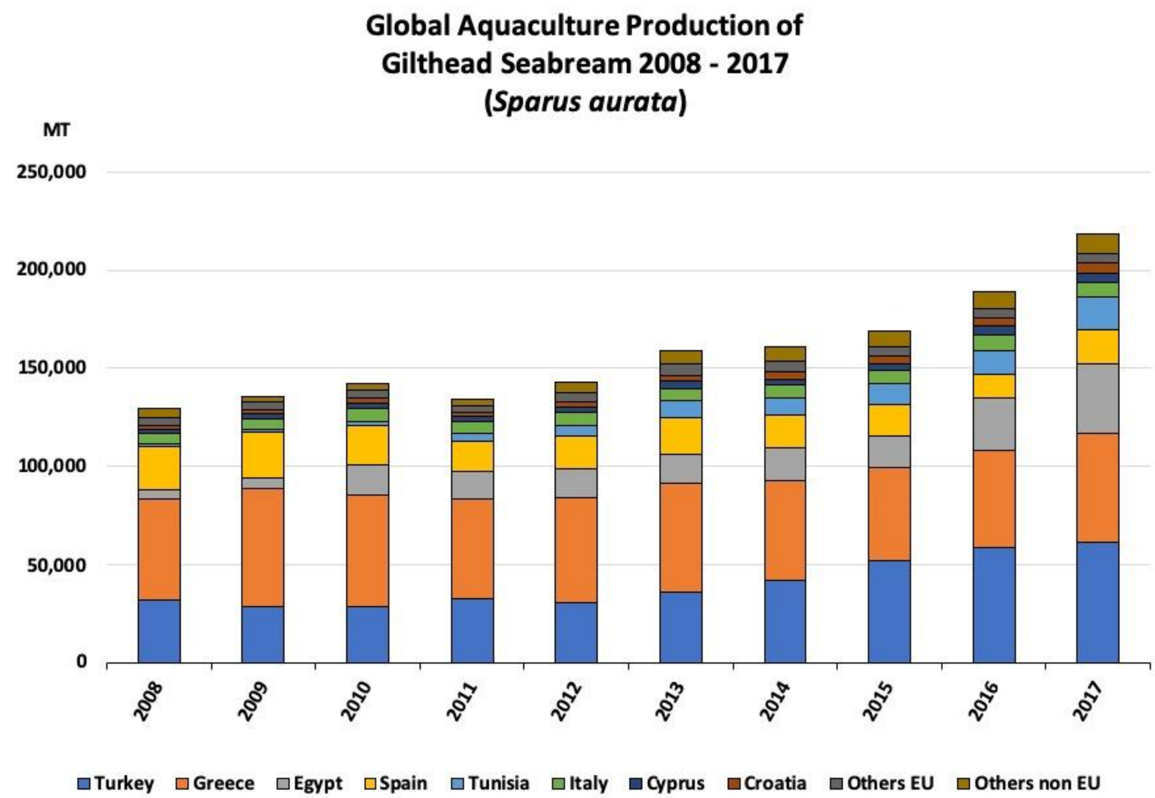


Figure 3: Global aquaculture production of gilthead seabream, 2008-2017 (FAO 2019)

European Seabass

The first country to report production of cultured European seabass to FAO was also Italy; this occurred in 1973. Six years later, Greece and Portugal became the next countries to report production of this species. The most recent data from FAO indicates that by 2017, total global cultured production of European seabass was 215,636 MT (Figure 4) and the scope of this report incorporates over 97% of this volume. Throughout the 1990s, Greece was the main producer of this species but, in 2004, Turkish production volumes overtook those of Greece. Turkey has remained the most dominant producer of seabass up until the present time, accounting for over 46% of production in 2017, compared to Greece's share of just under 21%.

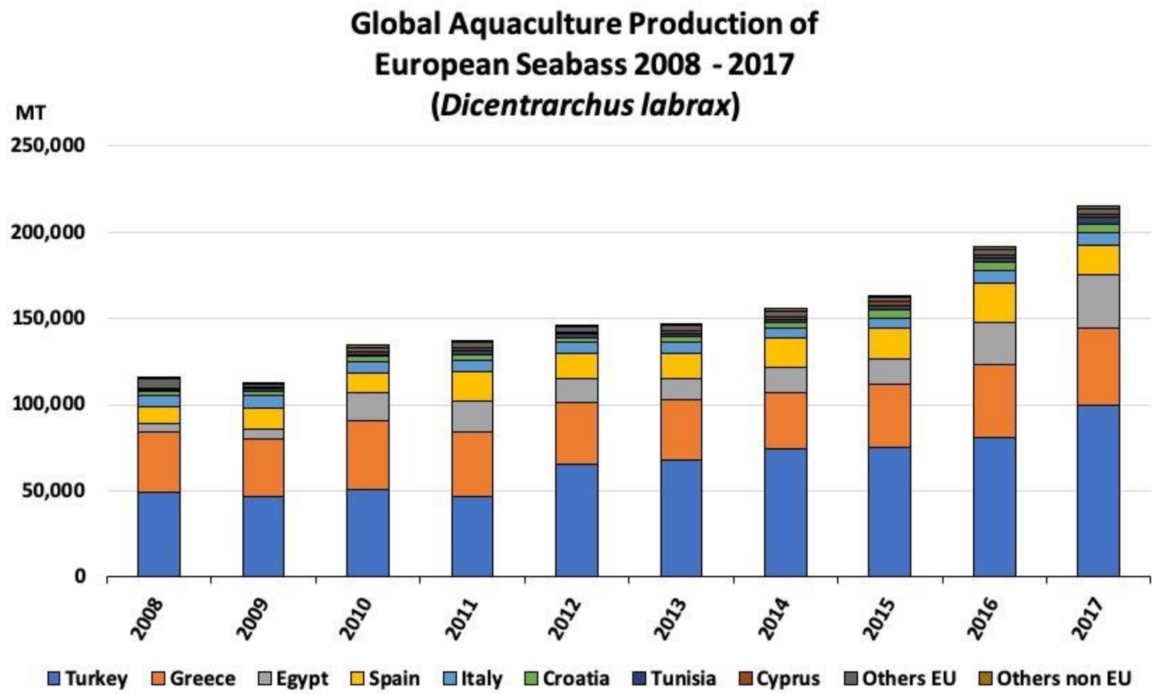


Figure 4: Global aquaculture production of European seabass, 2008-2017 (FAO 2019**)**

Meagre

In 2017, global production of meagre was 31,935 MT; Egyptian production, at 25,013 MT, accounted for over 78% of this amount. Cultured production of this species was first reported to FAO in 1997 by France. A few years later, a number of other EU counties also started reporting small production volumes: Italy in 2002, Spain in 2003 and Portugal in 2005. In 2008, Egypt became the next country to report farmed production of meagre to FAO and this nation has remained the dominant producer of this species since this time. Egypt's dominance in the cultured meagre sector is clearly evident in Figure 5; the total aggregate production of this species reported to FAO to date (i.e. from 1997 to 2017) is 138,483 MT, of which Egypt has produced 71% (98,225 MT). The second largest producer is Spain, which accounted for 11% of the entire reported production volume. The scope of this report incorporates virtually all (99.86%) of the total combined global aquaculture production of cultured meagre. Meagre has been identified as an emergent aquaculture species with great potential by the Diversify project, an initiative funded by the European Commission. The project, which has a particular emphasis on encouraging the development of cage farming in the Mediterranean, has also identified other promising new species in its efforts to encourage expansion of aquaculture in the EU (The Fish Site 2016).

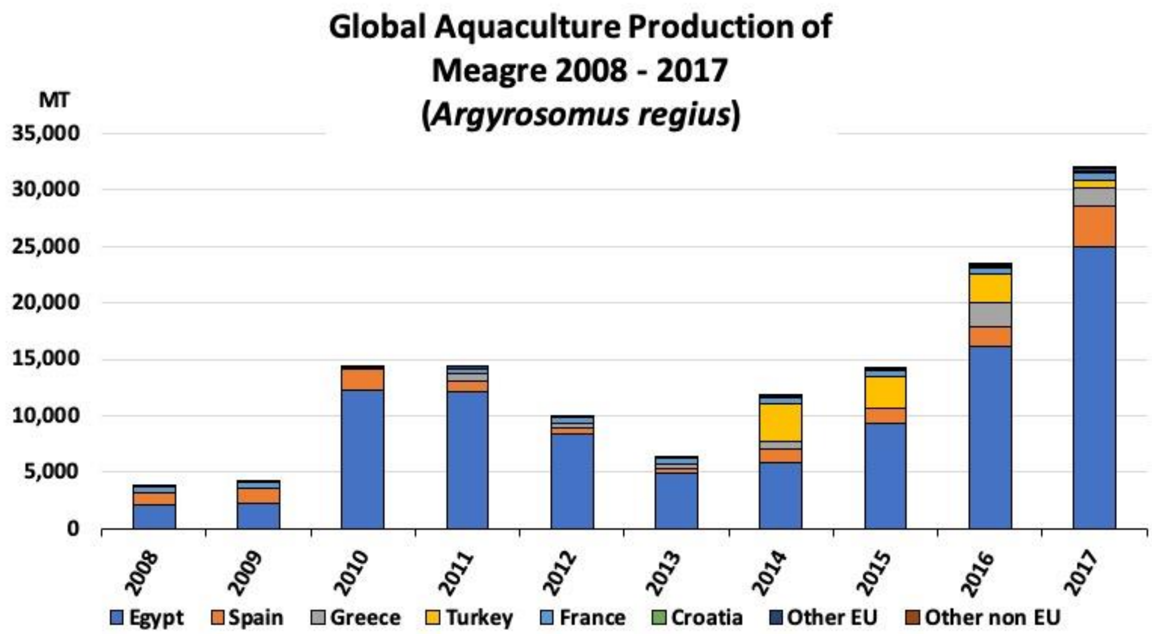


Figure 5: Global aquaculture production of meagre, 2008-2017 (FAO 2019**)**

Industry Scale and Production Systems

Culture of gilthead seabream and European seabass is a well-developed industry in the Mediterranean, Black Sea and North-Eastern Atlantic regions (Eurostat 2018a, Eurostat 2018b). When production rose exponentially in the 1990s, more players were attracted to invest in the sector. This ultimately led to market over-supply and a subsequent slump in ex-farm prices, which in turn led to many smaller producers being bought out and consolidated into the portfolio of larger companies, such that there are far fewer small operators nowadays (UCN 2017). Aquaculture production of seabream and seabass in the Mediterranean region has continued to increase since 2000, primarily been due to expansion in the Greek and Turkish sectors (AquaSpace 2018b). Most grow-out takes place in near-shore, floating net-pens and this is the production method favored by the main producing nations; however, around 15% is reportedly produced in land-based pond systems in countries such as Portugal and Italy (Gausen et al. 2014). Pond culture is also used predominantly in Egypt in the Nile delta region, with only a small quantity of European seabass being produced in cages (FAO 2017b, Soliman & Yacout 2016, Abdelhamid et al. 2013). In recent years, several intensive desert farms have been established in Egypt also, which source brackish water from underground (Shaalan et al. 2017, Sadek 2013, Crespi & Lovatelli 2011). Multi-species cultivation is commonly practiced by farmers, due to the biological similarity of these fish, although each species is reared in a separate cage or pond so that appropriate husbandry can be provided to each.

Overview of the Main Producers

<u>Turkey</u>

The Turkish aquaculture sector has grown rapidly in the last decade to the extent that by 2017 it was the world's largest producer of both seabream (61,090 MT) and seabass (99,971 MT).

Turkey had been the global leader in terms of seabass production for some time but, prior to 2015, Greece had consistently been the largest volume producer of seabream since the early 90s. Turkey also started to produce meagre in 2014, when it reported a production of 3,281 MT, however, Turkish output of this species has declined each year since then and in 2017 only 697 MT was reported. Production of these three species is predominantly conducted in offshore ocean cages (Yücel-Gier et al. 2009) and large, offshore installations, producing over 1000 MT, have proliferated in recent years (Rad & Şen 2016). The majority (96%) of Turkey's seabream and seabass is farmed off the Aegean coast, primarily around Muğla and İzmir; another 3% is produced in the Black Sea; and 1% is cultured off Turkey's Mediterranean coast (Rad & Şen 2016). A few land-based farms also produce seabass in earthen ponds. In 2015, there were 427 licensed marine farming sites in Turkey, of which 380 were engaged in culturing seabream and seabass (Rad & Şen 2016). The majority of Turkey's fish processing facilities are approved, in accordance with EU regulation, to export to the EU, which is the recipient of around 65% of Turkish fisheries products - both cultured and wild[2]. Consolidated, vertically integrated aquaculture companies are increasingly the norm in Turkey (Eurofish 2018). Turkish company, Kılıç Deniz, is the world's largest producer of seabass and seabream. It exports to 60 countries: the US, Russia and Europe are its main markets[3].

Greece

Aquaculture represents 69% of seafood production in Greece, with the balance coming from wild-capture. Marine fish farming, predominantly seabass and seabream, accounts for 97% of the volume (and 98% of the value) of the country's cultured fish production (FGM 2017). In 2017, Greece produced 55,948 MT of seabream and 44,285 MT of seabass, making it the second largest global producer of both of these species behind Turkey - it should be noted, however, that prior to 2015 Greece was the world's largest producer of seabream. Turkey's production increased in 2015 and Greece's decreased, likely as a result of the economic and political turmoil that the country experienced that year. In 2016, 31% of total global sales of seabream and seabass, and 59% of total EU sales of these species, were of Greek origin (FGM 2017), however, Greece has lost some of its market share in recent years to Turkish production, especially due to the pricing advantage that Turkish producers have had over Greek producers of late (GLOBEFISH 2019). Like Turkey, Greece is highly export-oriented, with only 22% of seabream and seabass production remaining on the domestic market. Of the balance that is exported, Europe absorbs more than 90% (Italy is the biggest importer followed by Spain then France) (FGM 2017) and 4% is sold into North American markets (FGM 2016). In 2015, 0.4% of Greek seabream and seabass production was certified EU Organic (EUMOFA 2017). A small amount of meagre is also farmed, which comprised 1,634 MT in 2017 (FAO 2019). In 2017, Greece had 63 aquaculture companies which were operating 366 farms - and most of these were small, family-run enterprises (FGM 2017). However, the industry has seen a great deal of consolidation in recent years, with four companies dominating the national seabass and seabream sector: Nireus, Selonda, Andromeda and Galaxidi (Nireus 2019, Selonda 2019, AG

[2] https://www.eurofish.dk/turkey
[3] https://www.seafoodsource.com/news/aquaculture/record-exports-for-leading-bass-bream-producer

2019, GMFSA 2019). Toward the end of 2019, further consolidation occurred when the Andromeda Seafood Group acquired both Nireus and Selonda (SeafoodSource 2019).

Spain

Spain is both the largest producer and consumer of fishery products within the EU: 70% of production is wild capture (ocean), 29% aquaculture, and 1% wild capture (inland). National aquaculture production includes around thirty different species; gilthead seabream and European seabass are the main marine species produced. In 2017, Spain produced 17,005 MT of seabream, 17,656 MT of seabass, and 3,524 MT of meagre. Three-quarters of farming operations are small, with less than five employees each. In 2015, there were 96 farms producing seabream and seabass (Eurofish 2018). Culmárex Group, which is a subsidiary of Cooke Aquaculture, is Spain's largest producer of seabass and seabream (Culmárex 2018). Meagre production was first reported by Spain in 2003; this species has the potential to become a more significant player in the Spanish aquaculture sector going forward (Eurofish 2018).

Croatia

In 2015, Croatia had 373 registered fish farms producing marine species, and this was mainly comprised of seabream, seabass and bluefin tuna (ranching). Croatia played a pioneering role in the development of seabass larval rearing and was home to one of the first and largest hatcheries for this species in the early 1980s (Eurofish 2018). In 2017, Croatia produced 4,830 MT of seabream, 5,616 MT of seabass and 253 MT meagre. Croatia's first FAO entry for production of meagre was recorded in 2010 (FAO 2019), although the country's first efforts to culture this species reportedly occurred around 2000. Croatia has a long coastline reaching along the Eastern Adriatic Sea; in the past, wild meagre used to be common in this region, particularly in estuarine environments, nowadays however, it is largely absent (Kružić 2016).

Cyprus

The Cyprus Department of Fisheries and Marine Research reports that there are presently nine operational/licensed ocean cage farms in the country, mainly culturing gilthead seabream and European seabass (DFMR 2018). These species dominate Cyprus' aquaculture production and, in 2017, the volume of seabream (4,949 MT) produced was more than double that of seabass (2,254 MT). Some small amounts of meagre production have been recorded since 2010 (FAO 2019).

France

France has a long tradition of aquaculture, but it is a net importer of seafood since national production is not sufficient to supply domestic demand (The Fish Site 2010). Around 50% of France's seabream and seabass imports come from Greece (GLOBEFISH 2019). Currently, there are 36 marine fish farming companies operating in the country, these produce sturgeon, turbot and sole, as well as seabass, seabream and meagre. These farms are mainly located along the Mediterranean coast (FranceAgriMer 2017). Seven of these companies focus on sturgeon production. The other marine farms are mainly very small and cultivation of seabass, seabream and meagre is dominated by just three companies (pers. comm. Jérôme Lafon, FranceAgriMer, March 2019). The largest of these companies, Gloria Maris, reportedly produces almost 80% of the country's cultured marine fish (UCN 2017). Twenty percent of French seabass and seabream production is certified EU Organic (EUMOFA 2017). In 2017, domestic aquaculture production included 1,400 MT seabream, 2,200 MT seabass and 600 MT meagre (FAO 2019). France is renowned for its expertise in fish reproductive management and juvenile production (FFUS 2015).

Italy

Small enterprises, with under 5 employees, dominate the aquaculture sector in Italy. Although seabream and seabass are the main finfish that are cultured, around 30 species are produced, including bivalves. Aquaculture takes place in all coastal regions, but the Adriatic region is particularly well-developed. So-called valliculture, a traditional form of extensive aquaculture, is also practiced; this takes place in natural, brackishwater lagoons (called "valli") and occurs predominantly in the north-east of the country (Eurofish 2018). Italy is the main importer of seabream and seabass produced in Greece, accounting for about 40% of the former and 50% of the latter (GLOBEFISH 2019). In 2017, Italy produced 7,600 MT seabream, 6,800 MT seabass and 100 MT meagre (FAO 2019).

Portugal

Production of seabream and seabass is limited and takes place in earthen ponds (OSPAR 2009); ocean conditions (waves and currents) and temperatures are not conducive to ocean farming of these species and offshore cage farming is not practiced as yet (Encarnação 2016). In 2017, Portugal produced 1,200 MT seabream, 400 MT seabass and 70 MT meagre (FAO 2019).

Egypt

The main marine species cultured in Egypt is mullet, which accounts for almost three-quarters of all marine production; the rest is comprised of seabream, seabass and meagre, plus a very small quantity of shrimp. In contrast to the cage culture techniques practiced in the EU and Turkey, Egyptian seabream, seabass and meagre production is almost exclusively reliant on semi-intensive pond culture (GAFRD 2018b), although a small amount of cage production also occurs (Soliman & Yacout 2016). For the purposes of this report, those ponds which apply manufactured, commercial diets as feed are considered semi-intensive, while those which apply whole fish as feed (some meagre production, see Criterion 5) are considered semi-extensive. Damietta Governorate, which is located in the northeast of the Nile delta on the Mediterranean coast, is where 91% of seabass, seabream and meagre production takes place (GAFRD 2018b), particularly in the area known as the Deeba Triangle, which is located in the north-western part of Lake Manzala (El-Mezayen et al. 2018, USDA FAS 2016, Abdelhamid et al. 2013, FAO 2010). The balance of production comes from the neighboring governorates of Port Said, Alexandria and Suez. Egypt's Mediterranean coast is shallow and exposed to winds, therefore not well-suited to cage farming, and the Red Sea, which is a major tourist destination renowned for its beaches and coral reef, is also not well-appointed for aquaculture developments (MADE 2013). In recent years, several intensive desert farms have been established; these facilities source brackish water from underground (Shaalan et al. 2017, Sadek 2013, YouTube 2012, Crespi & Lovatelli 2011, DailyNews 2010) and a few farms are producing seabream and seabass in areas where the salinity is >26 g/liter (Soliman 2017). One of the General Authority for Fisheries Resources Development's (GAFRD) stated policies is to promote the use of desert land for aquaculture (Goulding & Kamel 2013).

Although Egypt is not presently identified as an exporter of seabream, seabass and meagre to North American markets, they are a significant aquaculture producer; in 2017, 21% of the total production considered in the geographic scope of this report came from Egypt, up from 12% in 2015 (FAO 2019). During the last two decades, aquaculture in Egypt has been on a rapid growth trajectory (Shaalan et al. 2017). To put this growth into perspective, the following illustrates how much the production volumes of these three species has risen during the decade between 2008 through 2017: gilthead seabream production rose from 4,480 MT to 35,221 MT; European seabass production rose from 4,383 MT to 30,720 MT; and meagre production rose from 2,031 MT to 25,013 MT (note that 2008 was the first year that Egypt reported production of meagre to FAO). The nation's aquaculture production surpasses its wild capture fisheries output by a significant amount; if both of these seafood sources are considered together, the contribution from aquaculture rose from 65% in 2008 to 80% in 2017 (FAO 2019).

Although Egypt is a significant global aquaculture producer, most production is retained on local markets; in 2011, only around 1.5% of total production was exported (Goulding & Kamel 2013). Seafood exports reportedly reached 25,000 MT in 2015 and most of the fish included in this amount was gilthead seabream and European seabass (USDA FAS 2016). Extensive research on meagre culture is taking place in Egypt but culture of this species, plus culture of seabream and seabass, is reportedly heavily reliant on wild caught fingerlings with minimal amounts produced in hatcheries (FAO 2017b).

Import and export statistics:
Specific import/export codes, known as HS (international Harmonized System) codes exist for all internationally traded commodities. Specific HS codes have been assigned to gilthead seabream (*S. aurata*) and European seabass (*D. labrax*) - in fact there are three codes for each, which further define if the product is fresh/chilled, frozen or fillet. No such specific code has been assigned to meagre, which indicates that the volume of international trade in this species does not warrant individual classification. Any international trade in meagre would therefore be included in a generic heading with "other fish" and as such, specific trade data for this species is unavailable.

Despite the existence of specific HS codes for both gilthead seabream and European seabass, US importation statistics do not distinguish imports of either of these species using this level of granularity. Instead, imports of these species are categorized using a less detailed level of the code, which groups species of the same genus together; hence, imports of gilthead seabream are incorporated into the general "seabream" group, Sparidae spp., and European seabass is included as "seabass", together with other Dicentrarchus spp. This, compounded with the fact that no distinction is made between farmed and wild-caught product, makes it impossible to precisely quantify North American imports of cultured gilthead seabream, European seabass, and meagre using national statistics. However, by disregarding importation data from nations which do not farm gilthead seabream and European seabass, and only considering data from those countries that do, this allows for a more plausible assessment of the aquaculture derived import volumes of these species. These extracted data are presented in Figures 6 and 7. In 2018, the combined volume of seabream and seabass imports, from countries that culture gilthead seabream and European seabass, was almost 8,282 MT, of which 7% was seabream and 93% was seabass (NOAA 2019). Also, it is relevant to note that wild capture volumes of all three species is very minimal in comparison to aquaculture production. A review of FAO wild and cultured production data reveals the following: in 2017, 98% of reported European seabass was farmed versus 2% wild-caught; 95% of gilthead seabream was farmed versus 5% wild-caught; and 78% of meagre was farmed while 22% was wild caught (FAO 2019). These data indicate that virtually all imports of these species must be farmed.

<u>Gilthead Seabream</u>

Importation of seabream is first noted in United States importation statistics in 2012 and, since this time, Greece has been the dominant provider of cultured US seabream imports. In 2018, Greece accounted for 64% of US seabream imports (from countries that culture gilthead seabream) and a further 19% came from Turkey and 13% from Cyprus. In 2018, the entire amount of seabream imported from countries that culture gilthead seabream was 555 MT.

When the most recent production and importation figures are compared (i.e. 2017 FAO production data and 2018 US importation statistics), it can be extrapolated that around 0.25% of global production was exported to USA – although this assumption is based on the premise that all the imports under consideration originated from aquaculture, whereas it is highly likely that some of these imports included wild-caught seabream.

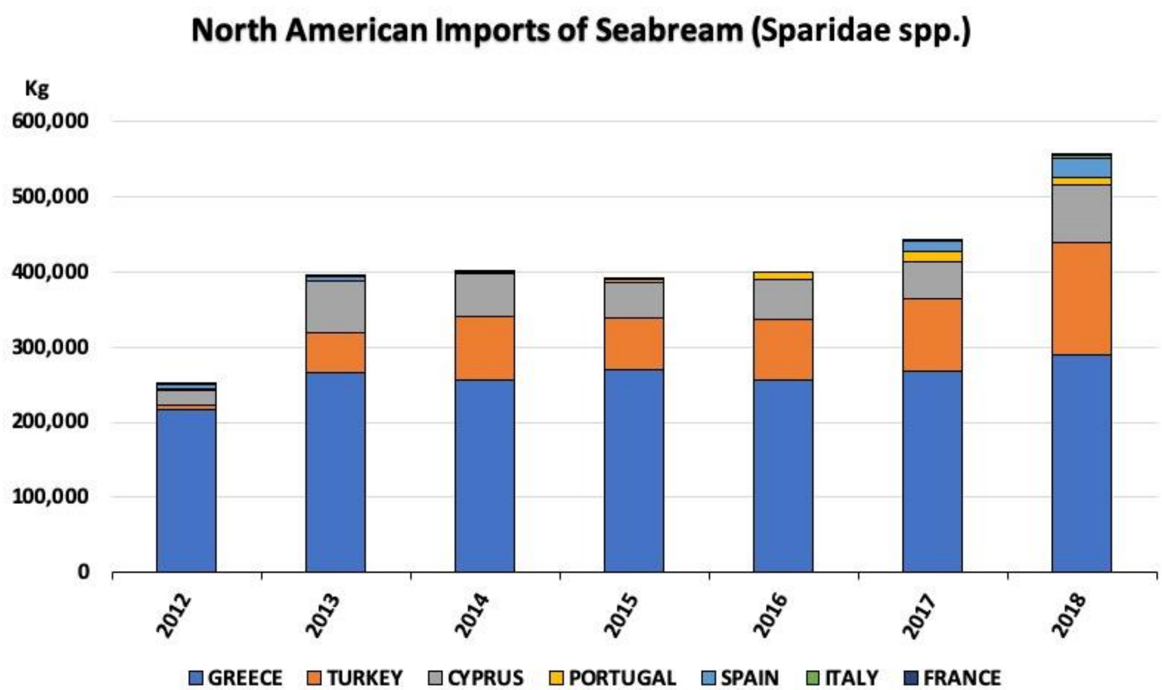


Figure 6: North American imports of seabream from countries that culture gilthead seabream (NOAA 2019)

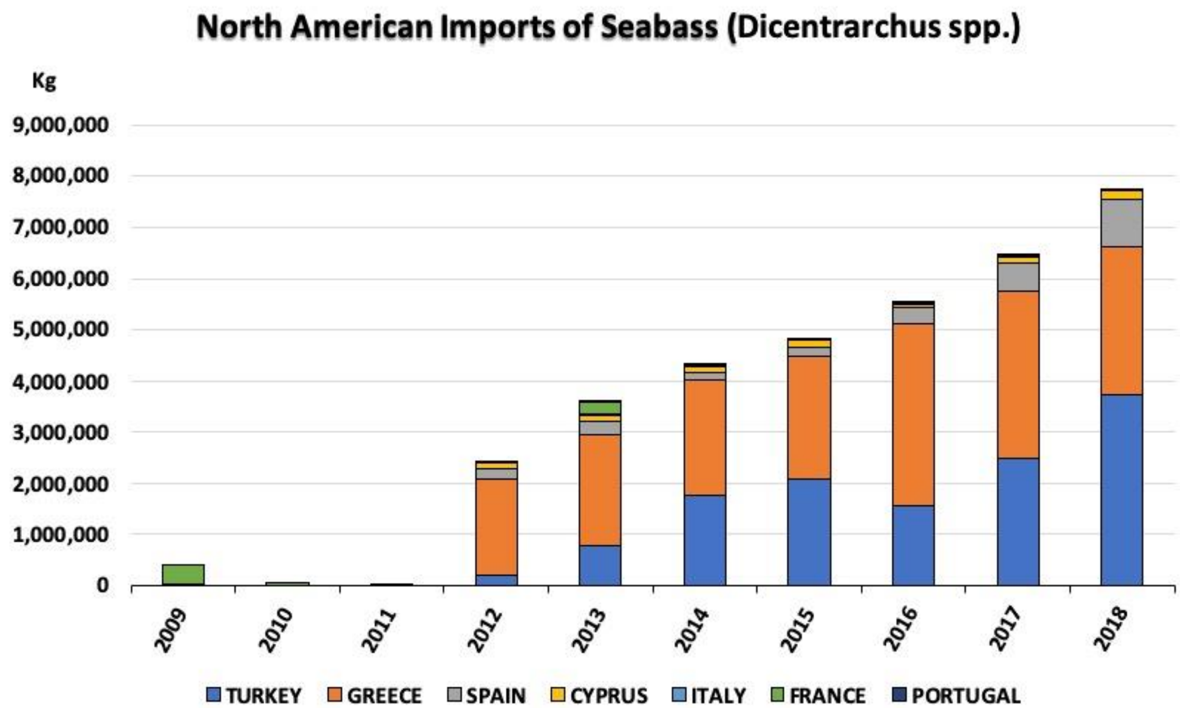


Figure 7: North American imports of seabass from countries that culture European seabass (NOAA 2019)

<u>European Seabass</u>

As noted in Figure 7, 'seabass' imports into the US from aquaculture producers of European seabass have grown exponentially since 2012. As with imports of seabream, Greece has been the dominant supplier of seabass in recent years, although in 2018 this trend changed: the most recent trade data show that Turkey provided 48% of imports in 2018, Greece 37% and Spain 9%. The entire amount of this species that was imported in 2018 was around 7,727 MT.

FAO's most recent global production figures for European seabass pertain to 2017. When these production data are compared with the most recent importation figures (i.e. US imports in 2018), it can be extrapolated that 3.58% of production was exported to USA – although this assumption is again based on the premise that all the imports under consideration originated from aquaculture, whereas it is highly likely that some of these imports included wild-caught seabass.

<u>Meagre</u>

As noted above, meagre has not been assigned a global trade code identifier, which indicates that trade in this species is minimal. If any of this species has been imported into North America, it would have been recorded in the "other fish" category. As is evident from Figure 5, Egypt is by far the global leader in terms of cultured meagre production – and it is notable that, even though Egypt also cultures both seabream and seabass, there have been no imports of these products from Egypt.

Non-US Exports

Seafish (2015) notes that around 90% of gilthead seabream and European seabass are consumed by domestic markets. Traditionally, seabream and seabass have been seasonally available products within their range, but with the development of aquaculture, they are available all year around. While Greece and Turkey are mainly export-oriented, other producer countries in the region, especially Italy, Spain and France, are also importers of these species (Eurofish 2014). Another major importer of these products is Russia (SeafoodSource 2018a). Egypt's domestic fish consumption is on the rise and its exports, primarily seabream and seabass, are modest in comparison, amounting to just 25,000 MT in 2015 (USDA FAS 2016). Egyptian aquaculture exports reportedly go to Gaza and Dubai; although Egypt can export wild capture fisheries to the EU, it has not been able to export aquaculture products there since 2002 due to non-compliance with Directive 96/23/EC, a sanitary requirement (Goulding & Kamel 2013), and this status has not changed in recent years[4].

Future Outlook for Seabream and Seabass Markets

FAO's 2018 Globefish report on the farmed seabream and seabass sector forecast that production of these species would increase by 5-7% during 2018. This report also noted that although it was apparent that global demand for these commodities had increased, the sector would be wary of creating downward pressure on prices in the event of over-supply (GLOBEFISH 2018). Now that the 2019 Globefish report has been released, it is evident that there has been a downward trend in the market, precipitated in particular by over-supply from Turkish producers in the last period. Sector expansion during recent years has been typified by such boom and bust cycles, and it is evident that the industry is very much in the 'bust' phase of this process at present. Looking to the future, the current Globefish report notes that despite current economic uncertainties in major markets for these species, the recent launch of the Aquaculture Stewardship Council's (ASC) new 'Seabass, Seabream and Meagre Standard' may provide opportunities for product diversification and differentiation, which may bolster the sector (GLOBEFISH 2019).

Product Forms and Common and Market Names

Gilthead seabream, European seabass and meagre are typically sold chilled as a whole, single portion-sized fish with minimal processing. Cultured fish of these species are generally harvested at around 300-500g (although meagre are often larger) and filleting, particularly with smaller-sized fish, is not practical.

[4] https://www.food.gov.uk/sites/default/files/media/document/fishery-products-guide-jan-2015.pdf

Table 1: Common and market names for the three species under assessment

Scientific Name	***Sparus aurata***	***Dicentrarchus labrax***	***Argyrosomus regius***
Common Name	**Gilthead seabream**	**European seabass**	**Meagre**
United States	gilthead bream	European seabass/ branzino/ branzini	meagre/ salmon bass
United Kingdom	gilthead seabream/ silver seabream	Mediterranean seabass/ branzino/ branzini	croaker/ meagre/ shadefish
Spain	dorada/ dourada	lubina/ mero/ robalo	corbina/ corvina
France	dorada royale/ laurata	loup de mer/ lubin/ bar Européen	bocca d'oro/ curbina/ aigle
Italy	orata	spigola/ branzino	ombrina boccad'oro
Turkey	çipura	levrek	sarağız balığı
Greece	χρυσόφα	Λαυρακόπουλο	Σολομός
Egypt	denis	karous	loot

Criterion 1: Data quality and availability

Impact, unit of sustainability and principle

- Impact: poor data quality and availability limits the ability to assess and understand the impacts of aquaculture production. It also does not enable informed choices for seafood purchasers, nor enable businesses to be held accountable for their impacts.
- Sustainability unit: the ability to make a robust sustainability assessment
- Principle: having robust and up-to-date information on production practices and their impacts publicly available.

Criterion 1 Summary: EU

Data Category	Data Quality	Score (0-10)
Industry or production statistics	10	10
Management	7.5	7.5
Effluent	7.5	7.5
Habitat	7.5	7.5
Chemical use	5	5
Feed	7.5	7.5
Escapes	7.5	7.5
Disease	5	5
Source of stock	10	10
Predators and wildlife	5	5
Introduced species	10	10
Other – (e.g. GHG emissions)	Not Applicable	n/a
Total		**82.5**

C1 Data Final Score (0-10)	**7.5**	**GREEN**

Criterion 1 Summary: Turkey

Data Category	Data Quality	Score (0-10)
Industry or production statistics	10	10
Management	7.5	7.5
Effluent	7.5	7.5
Habitat	7.5	7.5
Chemical use	2.5	2.5
Feed	7.5	7.5
Escapes	7.5	7.5
Disease	5	5
Source of stock	10	10

Predators and wildlife	5	5
Introduced species	10	10
Other – (e.g. GHG emissions)	Not Applicable	n/a
Total		**80**

C1 Data Final Score (0-10)	**7.3**	**GREEN**

Criterion 1 Summary: Egypt

Data Category	Data Quality	Score (0-10)
Industry or production statistics	7.5	7.5
Management	2.5	2.5
Effluent	2.5	2.5
Habitat	2.5	2.5
Chemical use	0	0
Feed	2.5	2.5
Escapes	7.5	7.5
Disease	2.5	2.5
Source of stock	2.5	2.5
Predators and wildlife	0	0
Escape of Secondary Species	10	10
Other – (e.g. GHG emissions)	Not Applicable	n/a
Total		**40**
C1 Data Final Score (0-10)	**3.6**	**YELLOW**

Brief Summary

Overall, there is an abundance of data available on the seabass, seabream and meagre sector in the EU and Turkey. Over the last few decades, as the industry has expanded throughout this region, the sector has benefited greatly from both European Commission-funded and industry-funded research efforts. This is testimony both to the economic importance of this sector and a growing awareness that environmental impacts need to be better understood for the industry to move forward. In addition to the prodigious volume of peer-reviewed, published literature that these endeavors have resulted in, there are also a great deal of collated government statistics available from across the region. Of note, significant differences were identified in the quality and availability of data pertaining to Criterion 4 – Chemical Use, thus the scores for the EU and Turkey were differentiated in this regard. The final numerical score for Criterion 1: EU – Data is 7.5 out of 10, whereas for Criterion 1: Turkey – Data it is 7.3 out of 10.

In contrast to the EU and Turkish sector, the availability of data pertaining to production of these species in Egypt is much less. Much of the data that is available comes from initiatives funded by international organizations such as FAO, WorldFish and CGIAR. According to FAO statistics, significant Egyptian production of these species only commenced around 2010, hence there has been limited time for literature on this sector to amass. Of additional note, only a few percent of Egyptian production are comprised of these species – a factor which partially elucidates the sparsity of data available. Notably, data concerning the sector's use of chemicals was not identified in literature and minimal information pertaining to management of the industry or effluent and habitat impacts were forthcoming. While feed data from commercial suppliers was easily obtained, it is hard to ascertain from the data available the extent to which commercial diets are implemented by the sector. Likewise, data pertaining to the source of stock criterion were sparse and data on predator interactions were not identified. Overall, the final numerical score for this category, Criterion 1: Egypt – Data, is 3.6 out of 10.

Justification of Rating

<u>Industry and Production Statistics</u>

Production statistics for this assessment have been sourced from the United Nations Food and Agricultural Organization's (FAO) global fisheries database, FishStatJ[5], as well as the European Commission's Eurostat database[6], plus Egypt's General Authority for Fish Resources Development (GAFRD)[7]. Up-to-date trade and industry statistics were informed by a variety of fisheries resources and publications such as FAO's Globefish[8] reviews, Intrafish[9], Undercurrent News[10] and SeafoodSource[11]. Additional industry information on the European sector was sourced from the Federation of European Aquaculture Producers[12] and Eurostat[13]. The quality of this data resulted in a high degree of confidence in its content as it pertains to the EU and Turkey and a data score of 10 out of 10 for this aspect of the Data Criterion. Industry and production statistics for the Egyptian sector were considered to be moderate-high and this resulted in a score of 7.5 out of 10 for this aspect of the Data Criterion

<u>Management and Regulations</u>

Publicly available data pertaining to management and regulation of the aquaculture sector in the EU and Turkey, as well as Egypt, is readily available online in both the FAOLEX database[14] and also in the General Fisheries Commission for the Mediterranean (GFCM)[15] web portal. GFCM materials also allow easy identification of the Competent Authority within each member country, plus the relevant data flow systems that are in place in each jurisdiction (GFCM 2018b). At the country level, there is also a great deal of information available concerning

[5] http://www.fao.org/fishery/statistics/software/FishStatJ/en
[6] https://ec.europa.eu/eurostat/data/database
[7] http://www.gafrd.org
[8] http://www.fao.org/in-action/globefish/background/who-we-are/en/
[9] https://www.intrafish.com
[10] https://www.undercurrentnews.com
[11] https://www.seafoodsource.com
[12] http://feap.info
[13] https://ec.europa.eu/eurostat
[14] http://www.fao.org/faolex/en/
[15] http://www.fao.org/gfcm/en/

management of aquaculture production in the EU and Turkey. Additionally, the European Parliament provides online access to information pertaining to governance of the sector in each of its member states[16], and the EURLex[17] web portal provides access to European Union Law. Multiple EU-funded, aquaculture-oriented projects have also been carried out, and the reports produced as a result of these initiatives, alongside peer reviewed literature on the sector, is considered to provide a reliable overview of sector management and regulations in the EU and Turkey. As such, data quality regarding management and regulations in the EU and Turkey is moderate-high and receives a score of 7.5 out of 10. In contrast, the volume of country-level data pertaining to the Egyptian sector is much less, however, and questions and uncertainties about the data that is available means that it is challenging to draw reliable conclusions on this topic. As such, data quality regarding management and regulations in Egypt is low-moderate and receives a score of 2.5 out of 10.

Criterion 2: Effluents & Criterion 3: Habitat

With reference to the EU and Turkish sector, an abundance of high-quality data was identified which informed a robust assessment of the Effluent and Habitat Criteria. The environmental impacts of aquaculture in the Mediterranean have been the focal point of numerous EU-funded initiatives over the last two decades and the topic has received much attention by researchers who in turn have published an abundance of literature on the subject. The MERAMED project, which studied the physical, biological and chemical effects of several cage farming sites in Greece, was instrumental in the early development of environmental management and monitoring tools that have guided the industry's development, and later the MERAMOD model was used to predict solid particle dynamics and the benthic impacts of wastes generated by seabream and seabass farms in a variety of diverse sites. Additionally, the MedVeg three-year project tracked nutrients released from Mediterranean fish farms and studied the effect they had upon macroalgae and seagrasses, particularly *Posidonia oceanica* meadows. An abundance of literature is available from all of these research initiatives. Similar studies were identified for fish farming sites in the Aegean Sea, where the bulk of Turkish production occurs, plus one recent study on production in the Black Sea. The EU's Horizon 2020 Framework Programme funds numerous on-going research initiatives, such as the AquaSpace project and the TAPAS project, which contribute to a robust overview of contemporary environmental monitoring and assessment practices within the EU and Turkey. In addition to these EU-funded research initiatives, the European Commission's web-based platform provides access to policy documents, regulations and directives, which facilitates an overview of the sector's regulatory framework with regard to environmental monitoring and management. Similarly, laws pertaining to the seabream, seabass and meagre sector in Turkey are accessible on the FAOLEX database web-portal. Other salient documents that have been pivotal in the formulation of environmental governance strategies for aquaculture across the EU and Turkey are the 2007 and 2009 guidelines produced by the Marine Programme of the International Union for Conservation of Nature (IUCN) as well as recommendations and resolutions published by the General Fisheries Commission for the Mediterranean (GFCM). Taken together, the quality of

[16] https://ec.europa.eu/fisheries/cfp/aquaculture/guidance-documents_en
[17] https://eur-lex.europa.eu/homepage.html

these data resulted in a moderate-high data score of 7.5 out of 10 for both Criterion 2: EU & Turkey – Effluents and Criterion 3: EU & Turkey – Habitat.

In Egypt, no specific studies on the effluent impacts of fish farms were identified, therefore the Risk-based assessment was used. Likewise, for the Habitat Criterion there was little data available and no studies were identified which explored the habitat impacts of farming seabream, seabass and meagre in Egypt. In the literature that is available on the Egyptian aquaculture sector, authors frequently comment on the dearth of information pertaining to the environmental impacts of fish farming, the lack of effective monitoring requirements, and the paucity of studies on the country's mariculture industry in general. Although a brief overview of laws governing the sector can be gleaned from a few academic papers plus a number of reports from international organizations (e.g. FAO[18], WorldFish[19], CGIAR[20]) and local government departments (e.g. the Ministry of Water Resources and Irrigation's National Water Resources Plan[21] and the Ministry of Environment's National Biodiversity Strategy and Action Plan[22]), there is little detail available that specifically defines the legal requirements of farmers or what their normal management practices are with regard to effluents. This lack of data has resulted in a data score of 2.5 out of 10 for Criterion 2: Egypt – Effluents and a data score of 2.5 out of 10 for Criterion 3: Egypt – Habitat.

<u>Criterion 4: Evidence or Risk of Chemical Use</u>
Publicly available data which explain the regulatory framework for chemical use in aquaculture in the EU and Turkey are readily available online; the Eur-Lex portal includes the array of laws relevant to this aspect of governance in the EU, whereas Turkish laws are accessible on the FAOLEX database. A recent review, which examined sea-based sources of chemical contaminants in European seas, was also helpful in informing research for this Criterion; within its contents were data showing which chemicals and therapeutants are approved for use in aquaculture within the region and their ecological impacts are also discussed. Also of great assistance were the websites of the European Medicine Agency (EMA)[23] and the European Centre for Disease Control (ECDC)[24], which detail the licensing procedure for veterinary medicines as well as the mandatory environmental risk assessment procedure that is in place; although some equivalent data was available on the Turkish sector, information pertaining to the EU sector is a great deal more comprehensive in this regard. Furthermore, the EMA's European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) reports[25], which document EU sales of veterinary microbial agents per food-animal group, per antimicrobial class, and by country, provide some data concerning the overall usage of such chemicals across

---

[18] http://www.fao.org/home/en/
[19] https://www.worldfishcenter.org
[20] https://cgiar.org
[21] https://www.mwri.gov.eg/en/
[22] https://www.cbd.int/doc/world/eg/eg-nbsap-v2-en.pdf
[23] https://www.ema.europa.eu/en
[24] https://www.ecdc.europa.eu/en/home
[25] https://www.ema.europa.eu/en/veterinary-regulatory/overview/antimicrobial-resistance/european-surveillance-veterinary-antimicrobial-consumption-esvac

the region. However, while this data does include a category for 'fish', which encompasses all aquaculture production, it does not disaggregate these data at the species level, thus the specific types, dosages and quantities of antibiotics used explicitly in the production of seabream, seabass and meagre are not identifiable. In Turkey, no equivalent data is available, thus even for the national aquaculture sector at large, published data on the sector's use of antibiotics is unavailable. Information regarding the environmental impacts of chemicals used by the aquaculture sector is limited, although several studies examining the presence of antimicrobial resistance genes on farms and farmed fish, both in the EU and Turkey, were identified. One recent study in Greece, which was conducted as part of the EU's ongoing TAPAS (Tools for Assessment and Planning of Aquaculture Sustainability) project, also provided some useful insights for this Criterion as it included an analysis of antibiotic residues in sediments and biota collected from 48 seabream and seabass farms. Since specific data pertaining to the sector's average on-farm usage of chemicals was unavailable in published data, and since such data are critical components in the assessment of this Criterion, further input was sought from numerous veterinary professionals across the EU and Turkey; these communications assisted in further informing this Criterion. When the quality and availability of data are taken into consideration, both with regard to published resources and personal communications, a greater degree of clarity was obtained with regards to the sector's chemical use practices in the EU than was available for Turkey. In light of this, the overall quality and availability of data to inform this criterion – the usage patterns, controls over, and ecological impact of chemicals - for this Criterion, as it pertains to the EU, is considered to be moderate, thus a data score of 5 out of 10 has been assessed for Criterion 4: EU – Chemical Use; whereas for Turkey, the availability of data is considered to be low-moderate, resulting in a score of 2.5 out of 10 for Criterion 4: Turkey – Chemical Use.

Data pertaining to chemical use by the sector in Egypt and its governance was not identified, although a number of studies were noted that discussed the emergence and development of AMR (antimicrobial resistance) in pathogens that affect the species under consideration. Culture of seabass, seabream and meagre in 2017 only constituted 6% of Egyptian aquaculture production (up from 3% in 2015), so a lack of data on this niche sector is perhaps not surprising. However, there is also a lack of data available on chemical usage by the Egyptian aquaculture sector in general, which, given the nation's globally dominant position as an aquaculture producer, is surprising. This lack of data has resulted in a data score of 0 out of 10 for Criterion 3: Egypt – Chemical Use.

Criterion 5: Feed

Feed data to inform this Criterion was obtained from the main feed suppliers to the geographical scope of this assessment. While a great deal of data used to inform this Criterion is available online, other aspects were gathered through personal communications. In order to protect the proprietary nature of these data, and also to provide an accurate overview of the sector, information from a variety of sources has been aggregated and formatted to present an average snapshot of the industry. Due to the size of the area covered in the scope, it was necessary to seek the advice of experts with relevant regional experience in order to determine the average economic FCRs of each species being considered. Numerous scientific papers from across the scope were also referenced during assessment of this Criterion, including a number of FAO documents. Additionally, the Sustainable Fisheries Partnership FishSource database was used to assess the sustainability and status of the reduction fisheries used as the source of fishmeal and fish oil in the dietary formulations under assessment. These data sources are considered to be robust and gave the assessor a high degree of confidence in the information they provided to inform this Criterion. This results in a score of 7.5 out of 10 for Criterion 5: Feed for the EU & Turkey. However, a reduction in this data score, as it pertains to the Egyptian sector, is warranted: although not apparent in identified literature, consultation with experts indicated that the meagre sector is known to use whole fish as feed. This illustrates that there are knowledge gaps in Egyptian data regarding the sector's feed use, thus the Criterion 5: Feed data score, as it pertains to the Egyptian sector, is scored 2.5 out of 10.

Criterion 6: Escapes

Despite the fact that fish farms in the Mediterranean do not have any legal requirements to report escape events, the issues surrounding escapes have attracted the attention of numerous researchers and there is a good deal of peer-reviewed literature available on this topic as it pertains to the EU and Turkey. Much data was generated by an EU-funded project, entitled 'Prevent Escape', the aim of which was to better understand the cause of escape events from open-net pen systems and to develop preventative solutions. Genimpact, another EU-funded study, also analyzed escape events and their potential for genetic repercussions upon wild conspecifics. In addition to the literature generated by these studies, there is also a significant body of literature which details re-capture efforts as well as studies which analyze morphological and molecular differences between wild and farmed fish. A number of documents are also readily available which detail best management practices for prevention and mitigation of escapes. A reliable representation of escape events and their subsequent ecological impacts was easily accessed to inform this topic, a data score of 7.5 out of 10 has been assessed for Criterion 6: EU & Turkey – Escapes.

Although there was not a great deal of data identified which referenced aquaculture escapes in Egypt, the data that were available are considered to give a reliable representation of the situation. A good overview of the areas where culture takes place and the likelihood of escapes occurring from pond systems was obtained from general literature on the sector, a particularly helpful resource was the USDA's Global Agricultural Information Network (GAIN) report on Egyptian aquaculture. Likewise, ample data was identified to ascertain that the majority of juveniles are wild-sourced. Although there was not an abundance of material available on this topic, it was adequate to inform this Criterion, subsequently, a data score of 7.5 out of 10 has been assessed for Criterion 6: Egypt – Escapes.

Criterion 7: Diseases

The pathology of seabass and seabream has been the focus of many European aquaculture research projects over the last few decades. As a consequence, there is a good deal of literature available on the topic with regard to EU and Turkish production, as well as researchers who were easy to contact and communicate with on the topic. In more recent times, as culture of meagre has developed, diseases of this species have been the subject of numerous research initiatives, some examples of which are the European Commission-funded five-year collaborative TargetFish project, which sought to prevent the spread of bacterial and viral diseases by developing new aquaculture vaccines and improving existing ones; also the ongoing MedAID (Mediterranean Aquaculture Integrated Development) project that aims to improve the competitiveness and sustainability of the marine fish-farming sector in the Mediterranean; and the ParaFishControl consortium, which seeks to address the impact of parasites on the sector and explore the feasibility of anti-parasitic vaccine development. These endeavors have resulted in much published data which greatly helped to inform the review of this Criterion. Disease transmission between wild and farmed stocks has rarely been documented but a few studies that attempted to do this, by implementing molecular tools, were identified. Information regarding the prevalence of pathogens, morbidity, and mortality on farms was obtained from literature and personal communications. A particularly valuable source of data in this regard was the Deliverable 1.2 report, produced by the Horizon 2020 MedAID project; this recent report provides survey data from seabream and seabass farms across the EU and Turkey and shows average mortality rates and their causes. The body of literature that is available concerning the disease status of the species under review and their potential ecological impacts are considered to provide a moderately reliable representation of the present situation and a data score of 5 out of 10 has been assessed for Criterion 7: EU & Turkey – Diseases.

Only a sparse amount of data was available to inform this Criterion with regard to the Egyptian sector. Although a detailed WorldFish report on Egyptian fish diseases exists, this review does not mention marine species and the pathogens that they are susceptible to. A large EU-funded survey, which sought to gain an understanding of the range and prevalence of aquatic animal diseases in North Africa, noted that only one useful response was received from the Egyptian sector. This lack of industry-response to information requests has also been the general experience of the author of this report. Of note, the annual survey of the European Union Reference Laboratory for Fish Diseases (EURL), which aims to track the development and impact of fish diseases on mariculture in the Mediterranean region, identifies viral encephalopathy and retinopathy (VER) as the disease of most concern in the North African region adjacent to the southern Mediterranean – however, viruses, including VER, are not mentioned by Egyptian researchers, save for one comment stating that there is little information available on viral impacts. While the data that is available from a few recent studies does offer some useful insights into a range of bacterial and parasitic impacts, it seems unlikely that these limited data sources fully represent the situation. Furthermore, no information concerning the potential impact of disease amplification and retransmission from farmed to wild stocks was identified. In light of this, a low-moderate data score of 2.5 out of 10 has been assessed for Criterion 7: Egypt – Diseases.

Criterion 8X: Source of Stock – Independence from Wild Fisheries

Data concerning the source of stock utilized by the EU and Turkish sector were considered to provide a highly detailed, complete and up-to-date overview of this aspect of production. Data resources included personal communications with experts, numerous peer-reviewed research papers, literature from the European Commission, industry publications and hatchery manuals. A great body of literature has been generated by the sector in the three decades since seabass and seabream hatcheries first started to operate in the Mediterranean region and robust data on this topic was easily accessible. This results in a high degree of confidence in the quality of data which informed this Criterion and a data score of 10 out of 10 has been assessed for Criterion 8: EU & Turkey – Source of Stock.

Data for the Egyptian sector was much less abundant and it was only through the application of assumptions and extrapolations that the degree to which the industry relies on wild collection of juveniles could be determined. Literature that informed this Criterion included FAO and WorldFish sector reports, GAFRD (the Egyptian General Authority for Fisheries Resources Development) statistics plus a small number of peer-reviewed papers. Although these data were considered to be reliable, no specific data was identified that robustly addressed the source of stock used by the sector, thus a low-moderate data score of 2.5 out of 10 has been assessed for Criterion 8X: Egypt – Source of Stock.

<u>Criterion 9X: Wildlife and Predator Mortalities</u>

Although data concerning wildlife and predator mortalities in the EU and Turkish sector is not abundant, it does adequately deliver a reliable representation of the typical predator and wildlife interactions that occur on farms within the scope. Literature concerning European Commission Directives, and guidance on the implementation of these, was informative and provided an overarching perspective on the governance framework in place with regard to this Criterion. Numerous studies on the sector refer in passing to predator issues and concur on the range of species involved; the population statuses of these affected species were clarified through literature and sources such as the IUCN. The number of studies specifically focusing on the impacts of predation are limited, although a few were identified, such as one which assessed the potential of fish farms to disrupt the migratory routes of predatory bluefish, and a nine-year long study which logged the observations of predation on a seabass and seabream farm during this period, particularly with regard to bottlenose dolphins. Despite this, no data quantifying mortality or other wildlife and predator interactions with farms were available, however information obtained via personal communications with industry experts indicates that these interactions do not commonly result in mortalities. A data score of 5 out of 10 has been assessed for Criterion 9X: EU & Turkey – Wildlife and Predator Mortalities.

There was a dearth of data pertaining specifically to the Egyptian sector and the species under consideration, although some useful information concerning wildlife and predator mortalities within the national fisheries sector in general was identified. This lack of specific data is perhaps unsurprising, since the target species of this report only comprise a small percentage of overall aquaculture production in Egypt. Data that was available to inform this Criterion included FAO publications and a few peer-reviewed studies, which discussed the general status of threatened and endangered species in the vicinity of the Nile delta and Egyptian Mediterranean coastal region, plus information concerning the invasive red swamp crayfish, which predates upon juvenile fish. However, since no sector specific data on this criterion were identified, the data score for Criterion 9X: Egypt – Wildlife and Predator Mortalities is 0 out of 10.

<u>Criterion 10X: Escape of Secondary Species</u>

The production of seabass, seabream and meagre within the scope of this assessment takes place in a contiguous waterbody, the Mediterranean Sea. Therefore, it is not considered to present a risk with regards to the unintentional trans-waterbody shipment of non-native species, and the data score for this Criterion is 10 out of 10.

Conclusions and final score

Overall, there is an abundance of data available on the seabass, seabream and meagre sector in the EU and Turkey. Over the last few decades, as the industry has expanded throughout this region, the sector has benefited greatly from both European Commission-funded and industry-funded research efforts. This is testimony both to the economic importance of this sector and a growing awareness that environmental impacts need to be better understood for the industry to move forward. In addition to the prodigious volume of peer-reviewed, published literature that these endeavors have resulted in, there are also a great deal of collated government statistics available from across the region. Furthermore, numerous academic and industry experts provided valuable input by responding to enquiries, which made a significant contribution to the volume of data that was taken into consideration during preparation of this report – particularly in areas where data gaps were identified in published literature. For the purposes of this report, a commonality of environmental impacts and management measures were often identified between the EU and Turkey, notwithstanding the significant governance differences in place in either jurisdiction. With regard to Criterion 4 – Chemical Use, however, there was a need to differentiate the data score to account for differences that were identified in the quality of data that was available to inform this Criterion. The final numerical score for Criterion 1: EU – Data is 7.5 out of 10, whereas for Criterion 1: Turkey – Data it is 7.3 out of 10.

In contrast to the EU and Turkish sector, the availability of data pertaining to production of these species in Egypt is much less. Much of the data that is available comes from initiatives funded by international organizations such as FAO, WorldFish and CGIAR. According to FAO statistics, significant Egyptian production of these species only commenced around 2010, hence there has been limited time for literature on this sector to amass. Of additional note, only a few percent of Egyptian production is comprised of these species – a factor which partially elucidates the sparsity of data available. Notably, data concerning the sector's use of chemicals was not identified in literature and minimal information pertaining to management of the industry or effluent and habitat impacts were forthcoming. While feed data from commercial suppliers was easily obtained, it is hard to ascertain from the data available the extent to which commercial diets are implemented by the sector. Likewise, data pertaining to the source of stock criterion were sparse and data on predator interactions were not identified. Overall, the final numerical score for this category, Criterion 1: Egypt – Data, is 3.6 out of 10.

Criterion 2: Effluent

Impact, unit of sustainability and principle

- Impact: aquaculture species, production systems and management methods vary in the amount of waste produced and discharged per unit of production. The combined discharge of farms, groups of farms or industries contributes to local and regional nutrient loads.
- Sustainability unit: the carrying or assimilative capacity of the local and regional receiving waters beyond the farm or its allowable zone of effect.
- Principle: not allowing effluent discharges to exceed, or contribute to exceeding, the carrying capacity of receiving waters at the local or regional level.

Criterion 2 Summary: EU & Turkey

Effluent Evidence-based Assessment

C2 Effluent Final Score (0-10)	5	YELLOW

Criterion 2 Summary: Egypt

Effluent Risk-based Assessment

Effluent parameters	Value	Score
F2.1a Waste (nitrogen) production per of fish (kg N ton-1)	125.85	
F2.1b Waste discharged from farm (%)	100	
F2 .1 Waste discharge score (0-10)		0
F2.2a Content of regulations (0-5)	1	
F2.2b Enforcement of regulations (0-5)	1	
F2.2 Regulatory or management effectiveness score (0-10)		0.4
C2 Effluent Final Score (0-10)		0.00
Critical?	YES	**RED**

Brief Summary

This Criterion has been split into two separate recommendations: one for the EU and Turkey and one for Egypt; this differentiation is required due to significant regional differences in both production systems and legislative framework.

Recent scientific review pertaining to the impact of effluents arising from farms culturing gilthead seabream, European seabass and meagre in the EU and Turkey concur that such farms do not generally cause nutrient enrichment that is detectable beyond ~100 meters of the cage field. Modern feeding practices, which utilize commercially formulated diets and feed monitoring equipment to minimize waste, have done much to diminish nutrient loading. The specific characteristics of each farm site play a major role in determining what the extent and severity of effluent impacts may be within each location, and some environments inevitably exhibit a greater degree of sensitivity than others. Effective site selection greatly reduces the potential for fish farm effluents to create negative impacts within the receiving waterbody, a concept which is widely implemented in the Mediterranean basin through use of allocated zones for aquaculture (AZA). In this regard, studies of seabream and seabass farms in Turkey and Greece have documented minimal negative trophic impacts occurring due to nutrients being released into the water column as a result of farming activity, and this is attributed to the highly efficient nutrient dynamics that exist between different tropic levels in such oligotrophic environments. Despite this, literature indicates occasional impacts to the benthic environment and sensitive seagrass beds have and do occur beyond the allowable zone of effect (AZE). To address this, both the EU and Turkey have enacted legislation that prohibits farming activities in the vicinity of sensitive habitats, thus in recent years farms have relocated further offshore, beyond the typical depth range of *P. oceanica* meadows. In Greek law, it is a prerequisite that farms must be sited away from seagrass meadows and in deeper water if they want to obtain permits for expansion, which in effect has moved the industry further off-shore. The situation is similar in Turkey: over a decade ago, legislation was passed which compelled farms to relocate into deeper water sites of 30 m depth or greater. However, at the regional level and over large marine areas, the potential cumulative impacts arising from dissolved nutrient dispersal and assimilation are poorly understood, highlighting the need for careful monitoring of industry expansion. The final numerical score for Criterion 2: EU & Turkey – Effluent – is 5 out of 10.

In Egypt, no specific studies on the effluent impacts of typical fish farms were identified, therefore the Risk-based assessment was used. This was assessed by analyzing two aspects of effluent impact: firstly, the biological wastes discharged by farms, based on average FCRs and protein content of feed, secondly, the content and enforcement of management measures. In the first instance, it was estimated that biological waste discharges from fish farms in Egypt are high; in the second instance, both the content and enforcement of management measures to mitigate the impact of fish farm effluents on the environment are lacking. The final numerical score for Criterion 2: Egypt – Effluent – is 0 out of 10 indicating that waste discharge is high and regulatory control and management is weak; this is considered a Critical conservation concern to Seafood Watch.

Justification of Rating

The environmental impacts of wastes discharged from fish farms are considered in both the Effluent and the Habitat Criteria; the former assesses the effects of discharges outside the farm boundary or beyond an allowable zone of effect (AZE), whereas the latter considers effluent impacts within the AZE, i.e. the immediate ecosystem inside the farm's boundary. There is inevitably a great deal of overlapping data taken into consideration in assessing these two criteria, however, the final scoring of each pertains to the distinct and separate impact zones described above. The General Fisheries Commission for the Mediterranean (GFCM) defines the AZE as follows: "*The area of sea-bed or volume of the receiving water body in which the competent authority allow the use of specific Environmental Quality Standard (EQS) for aquaculture, without irreversibly compromising the basic environmental services provided by the ecosystem*," and further clarify that "*The main idea is that within the AZE (i.e. in the immediate vicinity of the farm) some deviation from national and international standards is expected but not beyond a point (threshold) where critical goods and services provided by the marine ecosystem* *are irreversibly compromised*," (FAO-GFCM 2013). For the purposes of this assessment, the AZE is considered to be the area within 30m from the net pen edge.

Around two-thirds of the species covered in the scope of this report come from farm sites located in the northern Mediterranean and Black Sea countries. A further 20% (FAO 2017a) are produced at sites off the North Atlantic coasts of Spain, Portugal and France and the balance comes from Egypt. In contrast to the open net pen production systems utilized for these species in the EU and Turkey, much of Egypt's marine finfish production occurs in marine and brackish ponds and lagoons primarily located in the north-eastern Nile delta region, which is contiguous with the southern coast of the Mediterranean basin (Soliman & Yacout 2016, USDA FAS 2016, Abdelhamid et al. 2013, FAO 2010). In recent years, several intensive desert farms have also been established. These source brackish water from underground and a number of different finfish species are cultivated in these facilities, dependent upon the salinity of water, which varies between < 0.5 to 26 gr/L (Shaalan et al. 2017, Sadek 2013, YouTube 2012, Crespi & Lovatelli 2011, DailyNews 2010). Since the production systems used in Egypt are notably different to those used by the rest of the producers within the scope, and the availability of data is much less, the Egyptian sector is assessed separately for this criterion.

Evidence-based assessment: EU & Turkey
As the availability and quality of effluent data pertaining to production within the EU and Turkey is moderate-high (i.e. Criterion 1 score of 7.5 of 10 for the effluent category) the Evidence-based assessment has been utilized for this sector.

The organic wastes, nutrients and chemicals, which are generated as a by-product of farming fish in open net pens, inevitably flow unimpeded from the culture zone into the surrounding environment. These wastes primarily include fish feces and uneaten food, which are dispersed as solid particles, alongside dissolved nutrients (primarily nitrogen and phosphorus), which are released from the gills and also from the urine of fish. The deposition of particulate material is often regarded as the most significant cause of benthic impacts (Riera et al. 2017), although the effect that farming activity has upon the seabed, water column and surrounding environment varies according to the specific attributes of the farm, or cluster of farms, and how it/they are sited. Effective site selection greatly helps to mitigate against negative impacts of effluent dispersal. The greater the intensity of aquaculture in the region, and the shallower and less dynamic the flow of water is, the greater the potential for negative environmental impact (Massa et al. 2017, Mayor et al. 2017, SEP 2015, Price et al. 2015, IUCN 2009). The seabream, seabass and meagre sector in the Mediterranean started to develop rapidly in the mid-1990s, particularly in northern coastal areas. As expansion of the industry has continued, the need for improved, transregional, streamlined governance of the aquaculture sector became increasingly apparent to authorities both in the EU and also Turkey (Yücel-Gier et al. 2009). This has resulted in a regulatory framework that has evolved, and which continues to evolve, in response to the growth strategy of the sector and as a result of ongoing research. These legal instruments, and the research that has guided them, are explored in more detail below.

Recognition of the need for harmonized regional governance strategies

Development of aquaculture in the Mediterranean has primarily been driven by the seabream and seabass sector, which presently accounts for 95% of marine finfish production (AquaSpace 2018b). The need for a common and effective inter-regional approach to governance of the sector has long been acknowledged and is mentioned in numerous reports, some of which date back to the mid-1990s, an era that witnessed particularly notable industry expansion in Spain, Greece and Turkey (AquaSpace 2018b, IUCN 2009). However, since the Mediterranean basin touches the borders of 21 nations, realization of an effective, multi-regional governance strategy for the whole sector has proved challenging to implement (Karakassis 2013). With reference to the EU, even though there are over 300 EU rules that have regulatory ramifications for the sector, the efficacy of these legal provisions is ultimately dependent on how well they are administered at the regional level by EU member states (IUCN 2009). Progress toward harmonization of the sector has been an ongoing endeavor in recent years with numerous research initiatives contributing toward the realization of this goal.

Primary EU Directives and legal instruments governing environmental monitoring of fish farms

Two of the most important EU Directives that govern marine environmental policy, which thereby significantly affect regulation across the seabream, seabass and meagre sector, are the Water Framework Directive (WFD) (Directive 2000/60/EC) and the Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC), which were enacted in 2000 and 2008, respectively. The purpose of the WFD (Directive 2000/60/EC) is to keep inland and coastal waters clean by controlling the input of nutrients and chemicals, whereas the MSFD (Directive 2008/56/EC) aims to make the seas 'clean, healthy and productive', requiring that member states develop strategies to achieve 'good environmental status' in their marine waters by 2020 and these strategies must be developed around eleven descriptors, which include minimization of eutrophication. These descriptors are explained in more detail in Criterion 3: Habitat. The MSFD Directive covers the area immediately beyond one nautical mile of the shore, whereas the WFD applies to the coastal area that reaches from the shore out to one nautical mile. Although Turkey is not in the EU, it implements comparable legal instruments to the WFD and MSFD (AquaSpace 2018b).

While the aforementioned EU legislation ensures that a common baseline of environmental standards is adhered to across the region, the adoption of EU Regulation No. 1380/2013 (EC 2013), effectuated by reforms to the Common Fisheries Policy (CFP)[26], further developed the EU's agenda on aquaculture. Adoption of this Regulation made it incumbent upon member states to develop their own multiannual national plans to facilitate the development of sustainable aquaculture within their own jurisdictions. The intent of these national plans is to further streamline, simplify and harmonize governance of the aquaculture sector in line with the EU's Blue Growth Strategy[27]. Included within Regulation No. 1380/2013 is Article 34, entitled 'Promoting sustainable aquaculture', which states that: "*With a view to promoting*

[26] http://www.europarl.europa.eu/factsheets/en/sheet/114/the-common-fisheries-policy-origins-and-development

[27] https://ec.europa.eu/maritimeaffairs/content/blue-growth-—-shaping-next-five-years-together_en

sustainability and contributing to food security and supplies, growth and employment, the Commission shall establish non-binding Union strategic guidelines on common priorities and targets for the development of sustainable aquaculture activities. Such strategic guidelines shall take account of the relative starting positions and different circumstances throughout the Union and shall form the basis for multiannual national strategic plans", and following on from this statement, the Regulation stipulates a number of aims, including the following:

By 30 June 2014, Member States shall establish a multiannual national strategic plan for the development of aquaculture activities on their territory. The multiannual national strategic plan shall include the Member State's objectives and the measures and the timetables necessary to achieve them. Multiannual national strategic plans shall, in particular, have the following aims (inter alia):

- *Administrative simplification, in particular regarding evaluations and impact studies and licenses;*
- *Indicators for environmental, economic and social sustainability;*
- *Assessment of other possible cross-border effects, especially on marine biological resources and marine ecosystems in neighbouring Member States.*

The multiannual national strategic plans of all relevant[28] member states are now available on the website of the European Commission[29] and the strategic guidelines discussed in EU Regulation No. 1380/2013 are addressed in each of these country reports.

<u>Legislative adoption of IUCN guidelines for environmental monitoring</u>

Another major influencer of environmental policy in the region, as it pertains to aquaculture and specifically environmental monitoring, has been the Marine Programme of the International Union for Conservation of Nature (IUCN). The IUCN, through the collaborative efforts of the Centre for Mediterranean Cooperation, developed two extensive guides that promote sustainable growth of the sector, these were published in 2007 and 2009, respectively (IUCN 2007, IUCN 2009). The first guide focuses on interactions that occur between aquaculture and the environment. One of the main principles included in this guide is that: "*The organic matter in the effluents from aquaculture farms should, in quantity and quality, be capable of assimilation by the ecosystem, thereby not producing negative effects on the local environment*," (IUCN 2007) and the document goes on to provide management strategies to achieve this. The primary focus of the second guide is that of aquaculture site selection and site management, a core aspect of which is the application of best management practices in order to mitigation the potential environmental impacts of effluents and wastes discharged from fish farms (IUCN 2009). According to a recent EU-funded study, entitled Aquaspace, these guidelines have now been legally adopted by the majority of nations across the Mediterranean,

[28] Note: All member states of the EU, with the exception of Luxembourg, have produced a multiannual national strategic plan; Luxembourg has no commercial aquaculture, hence no plan is required from this member state.
[29] https://ec.europa.eu/fisheries/cfp/aquaculture/multiannual-national-plans_en

including Turkey, in that the concepts have been incorporated into local laws at the national level (AquaSpace 2018b).

FAO/GFCM guidelines for environmental monitoring

In 2012, in line with FAO's Blue Growth Initiative, GFCM adopted Resolution GFCM/36/2012/1, which promoted the implementation of allocated zones for aquaculture (AZAs) across the Mediterranean and Black Sea regions. (Note that while Turkey is not a member state of the EU, it is a member of GFCM.) In 2015, the GFCM Aquaculture Task Force was established to further develop transboundary strategies that would enable good governance of the sector (GFCM 2018a). To this end, resolution GFCM/41/2017/1 was adopted in 2017, which includes within its remit the harmonization of regional site selection strategies and carrying capacity evaluation methods within AZAs (GFCM 2017a). During their review of aquaculture in the Mediterranean, the EU-funded Aquaspace study found that the AZA concept had been widely implemented by farms producing seabream, seabass and meagre throughout the region (AquaSpace 2018a), and this status is echoed by numerous other authors (FAO 2018a, FAO-GFCM 2013, Hilmi et al. 2015, Sanchez-Jerez et al. 2016). Given the dominance of Turkey and Greece within the seabream, seabass and meagre sector, it is pertinent to note that these nations adopted the principles of AZA in 2006 and 2009, respectively (AquaSpace 2018a). The concept of AZA is also integral to the EU's Integrated Coastal Zone Management (ICZM) Protocol (EU 2009b), which is discussed in more detail below. GFCM minimum guidelines for AZE environmental monitoring are shown in Figure 8; it is recommended that these parameters are tested twice a year, during opposite seasons, or, failing that, once a year during the period of maximum biomass (GFCM 2017b).

Water monitoring	Sediment monitoring
Temperature (°C)	Macro-benthic community
Salinity (psu)	Visual inspection
Turbidity (meters)	Redox potential (Eh, mV)[5]
Dissolved oxygen (% saturation; mg/l)	Sulphide (μM)
Chlorophyll a (mg/l)[6]	Organic matter (LOI, %)
pH (unit)	pH (unit)
TSM - Total Suspended Matter (mg/l)	Total Organic Carbon (TOC, %)[7]
POM - Particulate Organic Matter (mg/l)	Total Nitrogen (mg/g)
	Total Phosphorous (mg/g)
	Gas bubbles (Outgassing)
	Litter present on the seabed in the vicinity of the farm

Figure 8: GFCM minimum guidelines for environmental monitoring (GFCM 2017b)

Although research shows that monitoring programs have been implemented extensively across GFCM member countries (noted exceptions being Egypt, Montenegro, Lebanon, Albania and possibly Slovenia), the need for further uniformity of regulations and thresholds has been identified (AquaSpace 2018b). In their '*Guidelines on a harmonized environmental monitoring programme (EMP) for marine finfish cage farming in the Mediterranean and the Black Sea*' (GFCM 2017b), GFCM specify that:

The responsibility for the EMP and data recording should be:

- *Within the AZE: Aquaculture farms should record the data for the EMP. Alternatively, data collection will be under the responsibility of the competent authorities;*
- *Outside the AZE: data recording should be under the responsibility of the authorities in charge of granting maritime concessions and/or of environmental/nature protection.*
- *Data recorded within and outside the AZE should be analysed by the authorities in charge of granting maritime concessions and/or environmental/nature protection.*
- *The data and results from the EMP should be recorded and stored in a way that is easy to understand and which would be easily accessible for the sake of transparency, in order to strengthen the image of aquaculture products with the society at large.*

The ICZM Protocol

The ICZM Protocol (EU Official Journal L34/19, 4 Feb 2009) is a unique piece of legislation; globally, there is presently no other legal instrument which specifically governs ICZM (AquaSpace 2018a). With relevance to production of seabream, seabass and meagre in the region, the protocol draws on many of the guidelines put forth by IUCN and FAO/GFCM, such as those for effluent monitoring and the strategic implementation of AZA for site selection (AquaSpace 2018b). Article 19 of the Protocol states that EIA must be performed for "*Projects likely to have significant environmental effects on the coastal zones, and in particular on their ecosystems*, [and] *take into consideration the specific sensitivity of the environment and the inter-relationships between the marine and terrestrial parts of the coastal zone*," furthermore, *"Environmental assessments should take into consideration the cumulative impacts on the coastal zones, paying due attention, inter alia, to their carrying capacities*," (EU 2009b).

Research initiatives: Studies on the effects of effluent discharge at the local and regional level

Scientific research into the environmental impacts of aquaculture in the Mediterranean have been the focal point of many collaborative projects, which have been contributed to by multiple countries across the region (IUCN 2009). Over the last two decades, these collaborative efforts have resulted in a great abundance of literature on the subject (Karakassis 2013, Sanz-Lázaro & Marín 2008). The EU's Horizon 2020 Framework Programme funds numerous, contemporary research initiatives, such as the AquaSpace project (Ecosystem Approach to making Space for Aquaculture)[30] (AquaSpace 2018b) and the TAPAS (Tools for Assessment and Planning of Aquaculture Sustainability)[31] project (Telfer et al. 2018), both of which include refinement and streamlining of environmental monitoring and assessment within their remit.

[30] http://www.aquaspace-h2020.eu
[31] https://tapasproject.org

One of the 17 case studies discussed in the AquaSpace project focuses on aquaculture in the multiple Exclusive Economic Zones (EEZs) of the Mediterranean Sea. The report includes an overview of the specific geographical and biological qualities of the region, a focal point of which is the oligotrophic quality of Mediterranean waters. Typically, ocean primary productivity is nitrogen limited, but the Mediterranean's low level of nutrients means that primary production here is phosphorus limited, therefore eutrophication is only likely in this environment if phosphates are introduced (Aquaspace 2018b). The report additionally states that although the Mediterranean hosts many endemic species, their abundance is limited by these oligotrophic conditions (Aquaspace 2018b). These are important attributes of the region, which need to be taken into consideration when reviewing the potential regional impact of fish farm effluents (Karakassis 2013). The oligotrophic quality of the Mediterranean is such that photosynthesis occurs at greater depths than in many other water bodies, facilitated by heightened transparency of the water column (AquaSpace 2018b).

In the 2000s, a great deal of research efforts focused on the development of predictive deposition models. The 'Development of Monitoring Guidelines and Modelling Tools for Environmental Effects from Mediterranean Aquaculture' project, also known as the MERAMED project, studied the physical, biological and chemical effects of several cage farming sites in Greece and was instrumental in developing environmental management and monitoring tools for the industry (Black et al. 2002). Later, the MERAMOD (Predicting the deposition and benthic impact of aquaculture in the eastern Mediterranean Sea) model, which was based on an earlier monitoring tool developed for fish farms in Scotland, was used to predict solid particle dynamics and the benthic impacts of wastes generated by seabream and seabass farms (Cromey et al. 2012). MERAMOD was used to research and monitor impacts from a variety of sites which exhibited a diversity of characteristics in the Eastern Mediterranean Sea (Cromey et al. 2012). Although these deposition models have been fine-tuned and adapted for application in a variety of regional environmental settings and have been instrumental in refining site selection criteria to diminish the ecological footprint of farm effluents, they do not as yet appear to have been adopted into the compulsory regulatory approach of any producer nations, as has the modelling tool which was developed in Scotland (DEPOMOD: Predictive depositional modelling), which is now a compulsory element of the aquaculture licensing process in that country. Recently, a model has also been adapted to predict particulate dispersal from seabream, seabass and meagre farms in the North Atlantic, where oceanographic hydrodynamics are more vigorous than those in the Mediterranean. This region is called Macaronesia, hence the deposition modelling tool adapted for this area is called MACAROMOD (Riera et al. 2017).

<u>Protection of sensitive habitats: seagrass meadows and maërl beds</u>
Within the EU, both *Posidonia oceanica* meadows and maërl beds are protected under the Habitats Directive (92/43/EEC). In the 2000s, numerous research efforts were conducted in order to investigate the impact that nutrient release from Mediterranean fish farms had upon these sensitive habitats (Holmer et al. 2008, Diaz-Almela et al. 2008, Karakassis 2013). Seagrasses, which thrive in the Mediterranean's clear, oligotrophic coastal waters, are particularly sensitive to anthropogenic impacts, including those arising from fish farm effluents.

The region's most dominant, and ecologically important seagrass is *P. oceanica,* a species that has suffered significant decline over the last several decades (Homer et al. 2008, Huntington et al. 2006) and which can take decades (AquaSpace 2018b), even centuries, to recover from adverse impacts (Homer et al. 2008). Research has demonstrated that the potential impacts of fish farm effluents released in the vicinity of *P. oceanica* meadows varies greatly, depending on the specific characteristics of the site being studied (Price & Morris 2013). One such research initiative was the EU MedVeg project, which monitored and evaluated nutrient release from a number of seabream and seabass farms in Cyprus, Greece, Italy and Spain. Researchers concluded that the high level of primary productivity evident in the immediate vicinity of fish cages rapidly decreased with distance from the farms; the farthest limit at which nutrients were detected at any of these farms was 150 meters downstream in the dominant current direction (Dalsgaard and Krause-Jensen, 2006). Homer et al. (2008), a research team working on the same project, subsequently recommended that farming activities should be located at least 400m distance from *P. oceanica* habitats and this safety buffer is frequently cited in contemporary literature which discusses this topic also (AquaSpace 2018b, Karakassis 2013).

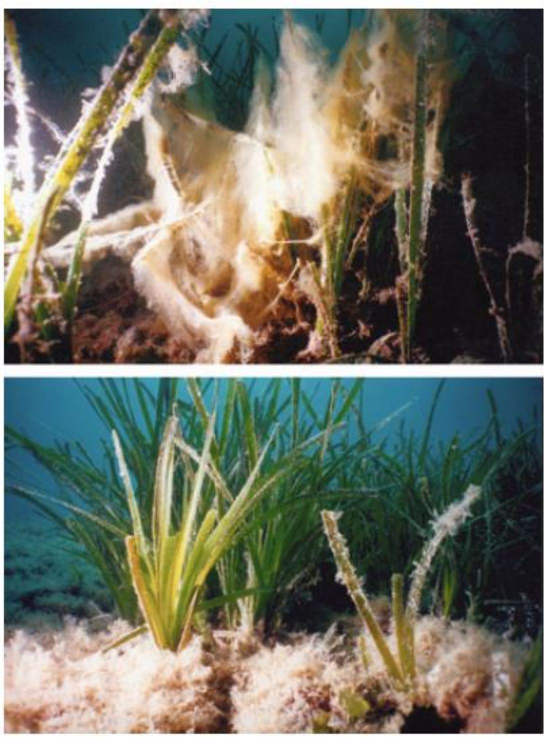


Figure 9: Appearance of the *Posidonia oceanica* meadow, at a distance of 80 m and 300 m from seabream and seabass cages sited in the Figari Bay (Corsica) during April 1994 (Pergent-Martini et al. 2006)

While the production volumes of seabass and seabream in the Mediterranean region have stagnated (GFCM 2018b) or remained flat in some European countries[32] since these nutrient release studies were conducted in the 2000's, Turkey and Greece, the two largest volume producers, have generally seen a year on year increase in output since this time (White 2017). Between 2005 and 2017, this has averaged a compound annual growth rate (CAGR) of 6.09% and 7.84% for Turkish seabream and seabass production volumes, respectively, whereas Greek seabream and seabass production has grown at a CAGR of 1.9% and 2.79%, respectively (FAO 2019). In 2008, a Greek study (Rountos et al. 2012) investigated the impacts on *P. oceanica* with specific reference to effluents discharged from seabream and seabass farms that were sited in shallow water. This study observed large rates of decline in seagrasses variously at 200m and 100m from farms; although some of this damage was evidently attributable to grazing herbivores (sea urchins and fish), the abundance of grazers was deemed to be a secondary consequence of the nutrient enrichment introduced into the vicinity by the farms. This study further flagged the need

[32] http://www.success-h2020.eu/case-studies/sea-bass-sea-bream/

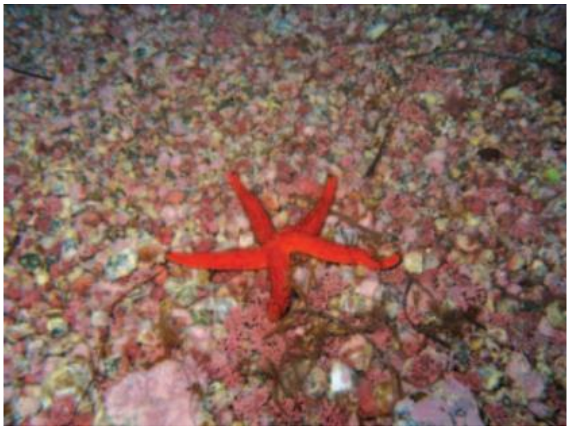


Figure 10: *Maërl* beds, such as this one photographed off the Spanish coast, are very sensitive to depositions from fish farms (Dempster & Sanchez-Jerez 2008)

for judicious site selection, which has been a guiding factor in more recent governance of the sector. In response to concerns of this nature, Greece introduced a new regulatory scheme for marine aquaculture in 2009, which prohibits fish farming in *P. oceanica* meadows (MEE 2015, Karakassis et al. 2013). While there are still a few old fish farms sited in such localities, the majority have reportedly relocated to other, deeper locations, beyond the typical depth range of *P. oceanica* meadows (pers. comm. Nafsika Papageorgiou, October 2019) and any farm sites which have not sought to relocate will automatically lose their concession to operate upon license expiry (pers. comm. Nafsika Papageorgiou, March 2020). In Cyprus it is also a prerequisite that farms must be sited away from seagrass meadows and in deeper water if they want to obtain permits for expansion (Kletou et al. 2018), thus farms that were previously in sensitive habitats have relocated (pers. comm. Periklis Kleitou, March 2020). This is also the case in Spain and Turkey, where AZA's stipulate the siting of farms in deeper water (> 30 m) (pers. comm. Nafsika Papageorgiou, October 2019; pers. comm. Ferit Rad, October 2019). Although farms at this depth could still potentially impact maërl beds, which can be found at depths of up to 30 m in the northeast Atlantic, down to 90 m – 100 m in the west Mediterranean, and in the eastern Mediterranean they can be found down to depths of 180 m (Barberá et al. 2003). Of additional note, one study in Spain which sought to determine if the effluents generated by off-shore fish farms can still impact near-shore *Posidonia* beds found that while there was no significant impact on the seagrass meadows, "*The idea that concentrating aquaculture facilities in offshore areas is a strategy totally exempt of environmental risk cannot be supported and hence site-selection processes for new aquaculture facilities must be careful with regard to the distribution of this and other sensitive habitats, even when these are located at distances greater than one kilometre*," (Ruiz et al. 2010).

Although it is not part of the EU, Turkey's regional governance framework and management strategies have been developed with the support of EU research initiatives (Aguilar-Manjarrez et al. 2017, Yücel-Gier et al. 2009), and often with reference to EU laws, as is shown in Figure 15 in the following Criterion (Criterion 4: Habitat). The environmental monitoring data that farms are required to collect are subject to frequent inspections by the Ministry of Food, Agriculture and Livestock as well as the Ministry of the Environment; if performance results fall below a certain threshold then licenses will be revoked (Yücel-Gier et al. 2009). The designation of aquaculture zones in Turkey was facilitated in 2006 with the passing of the most recent version of the Environmental Law No. 5491; the assignment and continued monitoring of these 'mariculture parks' has been achieved using the TRIX index, a monitoring tool originally developed by Vollenweider et al. (1998) which defines the trophic conditions of marine environments based on a range of water quality parameters, alongside other criteria pertaining to water currents, depth and the distance from shore. (Aguilar-Manjarrez et al. 2017)[33]. This act compelled fish farms to relocate from near-shore areas into deeper water sites (≥30 m) within one year of its legal adoption and prohibits farming activities in the vicinity of sensitive habitats, such as *P. oceanica* meadows (pers. comm. Ferit Rad, October 2019; FAOLEX 2019c, Aguilar-Manjarrez et al. 2017; Rad & Şen 2016, Balci Akova 2015). Posidonia meadows in Turkey are also protected by the 'Circular on sea and inland waters No. 37/1'[34].

A major factor that dictates the extent and severity of effluent impacts are the specific characteristics of the site location, and some environments inevitably exhibit a greater degree of sensitivity than others (Dempster & Sanchez-Jerez 2008). The authors of a Spanish study, which monitored the effect of seabass and seabream effluent upon maërl bed habitat (a type of calcified, unattached coralline algae), concluded that "*The benthic habitat beneath the fish farm, Maërl bed, was seen to be very sensitive to aquaculture impact compared with other unvegetated benthic habitats*," and that "*Environmental protection agencies should define different aquaculture waste load thresholds for different benthic communities affected by finfish farming, according to their particular degree of sensitivity, in order to maintain natural ecosystem functions*," (Sanz-Lázaro *et al.* 2011). Like, *P. oceanica* meadows, Maërl beds are protected by European legislation under the Habitats Directive (Council Directive 92/43/EEC) and the IUCN (2009) guidelines, which have largely been adopted across the region (AquaSpace 2018b) and encourage that a > 800m exclusion zone be designated around such sensitive habitats with regards to the siting of cage farms.

Regional impacts from dispersal of fish farm effluents

The area that is covered in the scope of this report includes multiple regions, which have a great diversity of climatic, hydrogeological, environmental and geomorphological characteristics. Within this scope, numerous reviews on the environmental impacts of fish farm sediments have been conducted in a variety of different settings and in consideration of a wide variety of site parameters and benthic habitats. In an overall review of the EU sector, the European Commission's Sustainable Aquaculture Brief comments that: "*Nutrients released from fish farms have the potential to cause eutrophication. There is evidence that levels of nutrients may be elevated up to a distance of about 100 metres around a farm, but there is, as yet, limited evidence of regional impacts"* (SEP 2015), although this document does reference a study (Sarà et al. 2011) in the Gulf of Castellammare (Italy), where chlorophyll-a concentrations were increased 3x-10x relative to open waters and was attributed to nutrient loading from seabream, seabass, and bluefin tuna farming in the region.

Figure 11 provides a spatial model of the dispersal of organic matter from an off-shore gilthead seabream cage farm. This farm is located in the North Atlantic, off the Canary Isles archipelago in an area which experiences strong tidal currents.

[33] https://www.ecolex.org/details/legislation/law-no-5491-amending-the-environmental-law-no-2872-lex-faoc065097/
[34] https://www.iucnredlist.org/species/153534/135156882

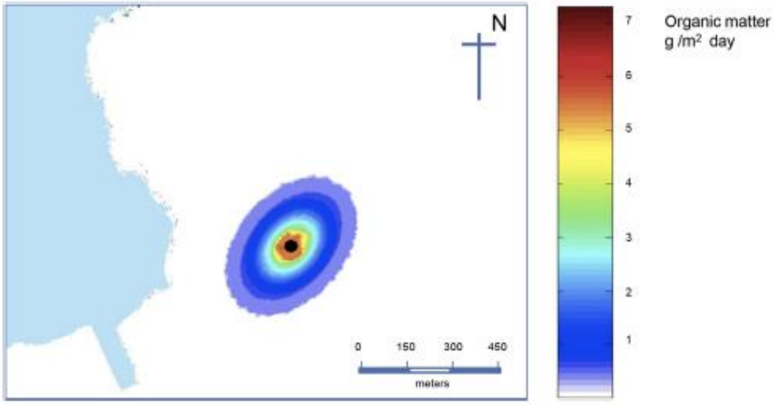


Figure 11: Simulation of areas impacted by varying daily sedimentation densities of organic matter from a 600 MT gilthead seabream farm located off the Canary Isles archipelago – the shaded central area is the estimated area occupied by the installation, which is comprised of 22 cages of 15m depth x 22m diameter (Rabassó & Hernández 2015)

A study by Price et al. (2015), which compiled an overview of recent global research efforts into the environmental impacts of mariculture on water quality and primary productivity, concluded that improvements in the management practices that are typically implemented by contemporary marine farms have done much to improve water quality in the vicinity of cage farms. The paper states: "*Effects on dissolved oxygen and turbidity are largely eliminated through better management. Nutrient enrichment of the near-field water column is not detectable beyond 100 metres of a farm when formulated feeds are used, and feed waste is minimized. We highlight the role of siting fish farms in deep waters with sufficient current to disperse nutrients and prevent water quality impacts*."

While production has remained fairly static in many Mediterranean countries, this is not the case with the two main producers, Turkey and Greece (FAO 2019, White 2017), thus it is interesting to consider the findings of the following two studies, both of which suggest that oligotrophic environments are very efficient at transferring nutrients up the food chain. A study of Güllük Bay in Turkey, the aquaculture zone where 55% of all national mariculture production occurs (Aguilar-Manjarrez et al. 2017), which analyzed water column nutrient concentrations and the accumulation of heavy metals in sediments caused by the sector's activities, concluded that, "*Results pointed out that concentrations of nutrients and heavy metals were in tolerable levels for the marine ecosystem. It is possible to conclude that the oligotrophic nature of the water in the study area was able to assimilate organic and inorganic loads produced by the fish farms*," (Basaran et al. 2010).

While these results are over ten years old now, the findings of a recently published Greek study, which analyzed historical and contemporary benthic sampling data from a bay where seabass and seabream had been farmed continuously since 1982, also concluded that oligotrophic environments are highly effective at assimilating nutrients arising from fish farming activities. The bay in question was shallow and sheltered, both of which are geographic features inherently more likely to limit the natural flushing of farm-generated wastes. The authors noted that, despite these predisposing factors, ecological deterioration was not detected, further indicating that nutrient-poor environments readily assimilate such farm inputs. This study provided an opportunity to review the long-term effects of production, utilizing twenty years' worth of monitoring data, from 1995 through to 2015, a time span which had seen an almost doubling of output from the farm (Tsikopoulou et al. 2019, Tsikopoulou et al. 2018).

Conclusions and final score: EU & Turkey

In conclusion, although farms culturing seabream, seabass and/or meagre do produce effluents that are detectable within the allowable zone of effect, evidence suggests that these effluents are generally easily dispersed by ocean currents as they move outside the immediate farm boundary and that they do not over-burden the carrying capacity of receiving waters at the local level; this appears to be especially so in the oligotrophic waters of the Mediterranean, where primary production is notably low, and warrants a score of 6 out of 10. Despite this, literature indicates occasional impacts to the benthic environment and sensitive seagrass beds have and do occur beyond the AZE, which warrants a score of 4 out of 10. To address this, both the EU and Turkey have enacted legislation that prohibits farming activities in the vicinity of sensitive habitats; thus, most farms have relocated further offshore, beyond the typical depth range of *P. oceanica* meadows, in recent years. In Greek law, it is a prerequisite that farms must be sited away from seagrass meadows and in deeper water if they want to obtain permits for expansion, which in effect has moved the industry further off-shore. The situation is similar in Turkey: over a decade ago, legislation was passed which compelled farms to relocate into deeper water sites of 30 m depth or greater. However, the impacts of fish farm effluents across large marine areas are not well-understood, meaning there is a potential for negative, cumulative effects at the regional level, particularly if industry expansion occurs. Overall, an intermediate score is applied, and the final numerical score for Criterion 2: EU & Turkey – Effluent – is 5 out of 10.

Risk-based assessment: Egypt

The Effluent Criterion considers environmental impacts that occur beyond the immediate farm area, i.e. outside the allowable zone of effect (AZE). As is described in further detail in Criterion 3 – Habitat, there is a dearth of information pertaining to the environmental impacts of fish farming in Egypt (AquaSpace 2018b, Soliman & Yacout 2015, Samy 2015) and a lack of effective monitoring requirements (El-Mezayen et al. 2018, Shaalan et al. 2017, FAO 2017b, Samy 2015, Sadek 2013, Goulding & Kamel 2013). Although one study was identified that modelled a simulation of dispersed uneaten feed and feces from a cage in Lake Maryut and followed this up by collecting field data, this study was not considered to provide ample evidence to inform this Criterion nor is it relevant to the majority of production, which predominantly occurs in earthen ponds – not cages (Brigolin et al. 2016, Abdelhamid et al. 2013). Due to a lack of data on this topic, (the Criterion 1 – Data score for the effluent category was 2.5 out of 10), the Risk-based assessment option was used instead.

Factor 2.1a – Biological waste production per MT of fish: Egypt

The Risk-based assessment uses species-specific economic FCR and feed formulation data in its scoring algorithm, therefore average values for all three species under assessment have been used to facilitate this calculation. Feed data for the following analysis comes from a number of sources. Specific details concerning feed components has been sourced directly through personal communications with the main manufactured feed suppliers to Egypt. These data have been further supported by information obtained from scientific literature, plus personal communications with industry experts. It should be noted, however, that cultivation of these species in Egypt is not necessarily always conducted solely with commercial diets; the use of whole fish, colloquially referred to as 'trash fish' (small tilapia, palaemonidae shrimp, sardines, etc.) has been noted in particular with meagre production (pers. comm. Dr. Shérif Sadek, December 2019). To take this into consideration, two separate calculations for meagre farmed in Egypt are presented below; the portion of meagre production that is produced in each method is unknown, and therefore each is considered to represent 50% of production and are averaged together to determine a single meagre score. The data in Table 2 shows how these average values have been derived – note that feed data is explored further in Criterion 5 – Feed.

Table 2: Metrics used to calculate average values for protein content of formulated feed, economic FCR and protein content of whole harvested fish with respect to the three species under assessment

	Seabass	**Seabream**	**Meagre**
Protein content of feed	42%	44%	43%
Economic FCR	2.3	2.0	1.7
Protein content of harvested whole fish	18.9%	19.2%	20.1%
% of total production of all 3 species (2016)	36%	40%	24%

With reference to Table 3, Factor 2.1a – Biological waste production per MT of fish – is calculated as follows:

- **Nitrogen Input** per MT fish produced = (a x e x b x 10) + c
- **Harvested Nitrogen Output** per MT fish harvested = (d x e x 10)
- **Biological Waste Production** per MT of fish = Nitrogen Input – Harvested Nitrogen Output

Table 3: Calculation of biological waste, i.e. nitrogen, produced per MT of harvested fish

	Seabass	**Metrics**
a	Protein content of feed	42%
b	Economic FCR	2.3
c	Fertilizer nitrogen input per MT fish produced	0
d	Protein content of harvested whole fish	18.9%
e	Protein nitrogen content factor	0.16[35]
	Biological Waste (N) Production per MT of fish	**123.32 Kg N/MT**

	Seabream	**Metrics**
a	Protein content of feed	44%
b	Economic FCR	2.0

[35] fixed value; protein is 16% nitrogen

c	Fertilizer nitrogen input per MT fish produced	0
d	Protein content of harvested whole fish	19.2%
e	Protein nitrogen content factor	0.16
	Biological Waste (N) Production per MT of fish	**110.08 Kg N/MT**

	Meagre (fed pellets)	Metrics
a	Protein content of feed	43%
b	Economic FCR	1.7
c	Fertilizer nitrogen input per MT fish produced	0
d	Protein content of harvested whole fish	20.1%
e	Protein nitrogen content factor	0.16
	Biological Waste (N) Production per MT of fish	**84.8 Kg N/MT**

	Meagre (fed whole fish)	Metrics
a	Protein content of feed	18%
b	Economic FCR	9.0
c	Fertilizer nitrogen input per MT fish produced	0
d	Protein content of harvested whole fish	20.1%
e	Protein nitrogen content factor	0.16
	Biological Waste (N) Production per MT of fish	**227.04 Kg N/MT**

The biological waste (N) production per metric ton of seabass is 123.32 kg N, of seabream is 110.08 kg N, and of average meagre (combined pellets and whole-fish fed) is 155.92 kg N. The industry average biological waste production per MT of fish (i.e. the weighted average per 2016 production figures) is 125.85 kg N/MT and is used as the final Factor 2.1a value.

Factor 2.1b – Production system discharge
This factor assesses how much of the waste produced by fish is actually discharged from the farm; it acts as a multiplier value (between 0 and 1) for Factor 2.1a. Soliman (2017) notes that: "*Most of the current production practices are carried out as run-through system with no recirculation of water or treatment of effluent prior to its disposal*". Without any data to indicate otherwise and based on the available scientific literature on nutrient dynamics in different aquaculture systems, it is assumed that 100% of the waste produced by the fish is discharged from flow through production systems in Egypt.

Final Factor 2.1 Score: Waste discharge
The Factor 2.1 score is the product of the amount of waste produced per MT of fish and the percentage of waste that leaves the farm. This value is allocated a 0-10 score based on an aquaculture-relative range from zero discharge (score 10) to a high discharge of >90 Kg N/MT (score 0 of 10). For each species under assessment (seabass, seabream, and meagre), the biological waste discharge per ton of production is >90 kg N, as is the aggregated weighted value used to represent all species (based on 2016 production; see Factor 2.1a); as such, the final score for Factor 2.1 for all three species is 0 out of 10.

Factor 2.2 – Management of farm-level and cumulative impacts: Egypt
Although Egypt is a major global aquaculture producer, the environmental impacts of the sector are not well-covered in legislation (FAO 2017b); neither are they well-documented or well-understood and numerous authors note that studies on this issue are lacking (Soliman & Yacout 2015, Samy 2015, Cataudella et al. 2015). El-Mezayen et al. (2018) note that in the Deeba Triangle, the main area where culture of seabream, seabass and meagre takes place, "*There is no monitoring of water quality, coastal aquaculture practices, and of the environmental factors that influence fish production in any of the multitude of fish farms*". As a result, the pursuit of data to inform Factor 2.2 is challenging. This Factor is further subdivided into two aspects: Factor 2.2a – Content of effluent management measures, and Factor 2.2b – Enforcement of effluent management measures.

Factor 2.2a – Content of effluent management measures

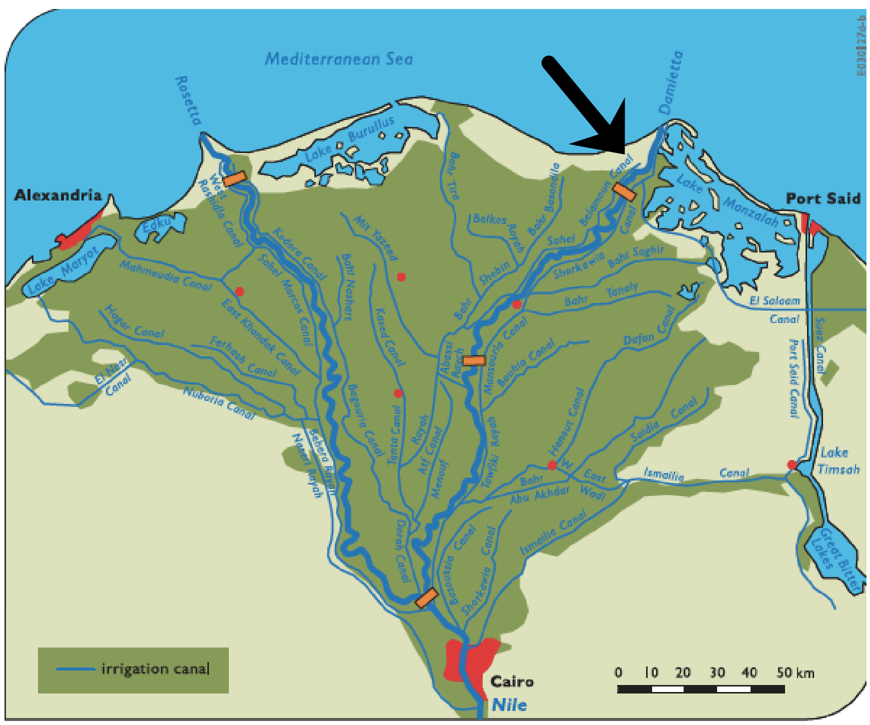


Figure 11: Irrigation canals in the Nile delta (NWRP 2017) – the black arrow points to Damietta Governorate, where 91% of seabream, seabass and meagre are farmed

Water management and access

Arable land and freshwater are extremely limited resources in Egypt since most of the land mass is covered in desert (Sadek 2013). There is virtually no rainfall in Egypt, which means that agriculture, which accounts for 95% of Egypt's water consumption, is almost exclusively dependent on water sourced from the Nile via a huge network of irrigation channels, which in turn is discharged into a vast network of drainage canals – picking up pesticide residues plus industrial and domestic effluents in the process (NWRP 2017). Water is a pressing, challenging and complex issue in Egypt and, unsurprisingly, laws that govern aquaculture are greatly impacted by this situation. Due to the scarcity of freshwater in Egypt, use of this resource is highly regulated and authorities have prioritized its use for agricultural activities and urban usage (Sadek 2013).

As stipulated in Law No. 12 of 1984[36] promulgating the Law of Irrigation and Drainage (and also Law No. 124 of 1983[37] regarding fishing, aquaculture and fish farms regulations), aquaculture cannot be conducted in environments that are suitable for agriculture, as defined by the Ministry of Agriculture (MoA), hence it is often practiced in areas where soil salinization has occurred and where the surrounding waters are brackish (Sadek 2013, USAID 2000). However, this law is not specific to aquaculture; rather, it is a broad legal instrument which governs general water management. Indeed, scant reference is made to the aquaculture sector in this piece of legislation and specific discharge limits for seabream, seabass and meagre farms are not explicitly included. The other principle law that deals with irrigation and drainage is Law No. 48 of 1982[38] which pertains only to inland waters and is concerning with the protection of the River Nile, on which Egypt is primarily dependent for its water needs (Goulding & Kamel 2013).

When water quality is mentioned in literature on aquaculture, the focus is mostly concerned with the fact that fish farmers must make do with polluted water that has already been contaminated by other upstream industries and users (as stipulated in Law No. 12 of 1984) – rather than the effects of effluents generated by aquaculture itself. Some authors have explored methods of treating influent water (Ghanem & Haggag 2015). A recent EU-funded project, which reviewed aquaculture production in GFCM member nations, noted that Egypt was one of the few countries in the region that had not implemented a monitoring program for aquaculture (AquaSpace 2018b).

<u>Overview of the regulatory framework which governs aquaculture in Egypt</u>
Egypt's political landscape has changed significantly during the last decade, including the introduction of a new amended constitution in 2014[39], which states that "*Environment protection is a national duty*" (CARE 2014). The new constitution specifically references provisions for fisheries and agriculture, although no specific mention of aquaculture is made. A review of the country profile for Egypt on FAOs FAOLEX database, which includes the country's policies, legislation and international agreements, indicates that little has changed in recent years in terms of governance of the aquaculture sector (FAOLEX 2019b).

The governing body which has overarching responsibility for the development of policies for agriculture and aquaculture is the Ministry of Agriculture and Land Reclamation (MoALR). With relevance to aquaculture, there are three agencies under the umbrella of MoALR: the General Authority for Fish Resource Development (GAFRD); the General Organization for Veterinary Services (GOVS); and the Central Laboratory for Aquaculture Research (CLAR). GAFRD, which was established with the passing of Law No. 190 of 1983[40], is the government agency which oversees the administration and enforcement of all fish production activities (both fisheries and

[36] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC121428
[37] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC121570/
[38] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC018642/

[39] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC127542/
[40] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC122312/

aquaculture); the main legal instrument applied by GAFRD is Law No. 124 of 1983[41]. According to Law No. 124 of 1983, a permit specifying the quantity and source of water for the farm plus the method of drainage and other conditions of use must be obtained from the Ministry of Water Resources and Irrigation (MoWRI) prior to obtaining a license from GAFRD (Goulding & Kamel 2013). Further details of these permit requirements could not be obtained.

With regards to wastes discharged from fish farms, this is governed by Law No. 4 of 1994[42], which was later amended by Law No. 9 of 2009[43] (Goulding & Kamel 2013). Formation of the Egyptian Environmental Affairs Agency (EEAA) was decreed with the passing of this law and, within its initial remit, this agency was tasked with the development of environmental policies, which it subsequently has the responsibility to implement and monitor. This law is relevant to the environmental governance of all industries though and fish farming is only specifically mentioned once, wherein it is stipulated that pesticides and other chemical compounds must not be sprayed near fish farms (EgyLaw4 1994). The annex section of the law includes specific allowable thresholds for an array of potential environmental pollutants pertaining to noise, air and water. Annex 1 of the Law, which is entitled 'Criteria and Specifications for Certain Substances when Discharged into the Marine Environment', is shown in Table 4.

While not specific to aquaculture, the guidance provided by Annex 1 is the only relevant provision in the law that specifies effluent limits for a number of water parameters. The preamble to this table notes: "*Without prejudice to the provisions of Law No. 48 of 1982 concerning the Protection of the River Nile and its Executive Regulations, the discharge of the substances indicated hereunder shall not exceed the levels indicated opposite each. In all cases, discharge into the marine environment is not permitted except at a minimum distance of 500 meters from the shoreline and may not be effected in fishing zones, bathing zones or nature reserves in order to preserve the economic or aesthetic value of the area*," (EgyLaw4 1994).

Of note, and as mentioned above, the referenced Law No. 48 of 1982[44] concerning the Protection of the River Nile and its Executive Regulations applies only to Egypt's inland waters (Goulding & Kamel 2013). These inland waters, as clarified in the law, include underground water reservoirs, thus the effluents generated by the few, recently established desert fish farms fall under the remit of this act. According to the law, an effluent discharge license must be obtained from the Ministry of Irrigation, "*Which will issue a decree according to the Ministry of Public Health recommendation to fix the measures and specifications concerning each case separately*," thus effluent discharge limits are prescribed on a case by case basis.

[41] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC018648/
[42] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC004984/
[43] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC152133/
[44] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC018642/

Table 4: Law Number 4 of 1994 Promulgating the Environment Law, Presidential, Decree, Egypt: Annex 1 - 'Criteria and Specifications for Certain Substances when Discharged into the Marine Environment' (EgyLaw4 1994)

Item	Maximum limits of Criteria and Specifications (mg/Ltr-unless otherwise indicated.)
Temperature	Not to exceed 10 degrees over the prevailing rate.
PH	6 - 9
Colour	Free of colouring materials
Biochemical Oxygen Demand (BOD)	60
Chemical Oxgyen Demand (COD)	100
Total Dissolved Solids	2000
Volatile Solids	1800
Suspended materials	60
Turbidity	NTU 50
Sulphides	1
Oil and Greases	15
Hydrocarbons of oil origin	0.5
Phosphates	5
Nitrates	40
Phenolates	1
Fluoride	1
Aluminium	3
Ammonia (nitrogen)	3
Mercury	0.005

Lead	0.5
Cadmium	0.05
Arsenic	0.05
Chromium	1
Copper	1.5
Nickel	0.1
Iron	1.5
Manganese	1
Zinc	5
Silver	0.1
Barium	2
Cobalt	2
Pesticides	0.2
Cyanide	0.1
Estimated Fecal Coliform Count in 100 cm3	5000

The EEAA is also the agency responsible for reviewing EIA applications (Goulding & Kamel 2013), though it is understood that an EIA is typically not required for culturing seabream, seabass or meagre in Egypt. Under current regulatory frameworks, an EIA is required for aquaculture production taking place in the open ocean, while aquaculture activities conducted in freshwater or brackish-water environments are still regulated by older legal frameworks through a variety of ministries that do not require an EIA (FAO 2009). The most recent 'Fish Statistics Year Book' published by GAFRD (2018b) states that production of seabream, seabass and meagre takes place almost exclusively in brackish and marine ponds, and thus production of the species under consideration is generally exempt from conducting an EIA.

Overall, the management structure governing aquaculture discharges appears to be unclear, and discharge limits into the marine environment are not specific to aquaculture. As such, the score for Factor 2.2a – Content of effluent management measures as it pertains to the farming of seabream, seabass and meagre in Egypt is 1 out of 5.

Factor 2.2b – Enforcement of effluent management measures

It is evident from a review of literature on the sector that legal instruments governing water quality and the control of effluents is a complex issue in Egypt, with multiple government agencies involved. The status of enforcement of regulations and management measures in

Egypt is summed up well in a recent report and strategy plan prepared by the country's Ministry of Water Resources and Irrigation (MoWRI): "*The management of pollution in Egypt is rather fragmented. Ministries have responsibilities for certain aspects, but there is no overall co-ordination. Although measures of prevention, treatment and impact modifying are being applied, they are not implemented on the basis of a common and co-ordinated set of priorities. Therefore, there is a need for more co-ordination between responsible institutions at the same level or between institutions at different levels, to allocate the resources in an optimal way. The rather 'vertical' institutional organisation of the government clearly hampers the management of an 'integrated' aspect as pollution control. As a result, effects of investments are not optimal. For example, when treated effluent is mixed with untreated effluent from other sources, the drain water is just as unusable as it was before*," (NWRP 2017). This MWRI strategy plan proposes a comprehensive review of the current policies, including those which govern aquaculture as mentioned in Factor 2.2a.

Similarly, the Ministry of Environment's National Biosecurity Strategy Action Plan for 2015-2030 (NBSAP 2016) comments on the challenges presented by "*Weak enforcement of laws related to pollution*" and highlights the need to "*Develop, monitor and enforce minimum national standards on soil, water and air quality*" as a Priority Action. The NBSAP also draws attention to the "*Lack of practical national guidelines for valuation of ecosystem services*", the "*Lack of common understanding of cumulative impacts on ecosystem services*", plus the "*Lack of capacity or human resources to conduct valuation of ecosystem services*" as impediments and includes within its targets: "*By 2018, ensure that the national strategy is supported by effective legislation and institutional frameworks to improve its enforcement*". An update on the progress of the NBSAP does not appear to be available as yet.

Limited evidence was found with regard to on-farm and discharged water quality from seabass, bream, and meagre farms in Egypt. One study conducted by El-Mezayen et al. (2018) found on-farm water quality to be on average largely compliant with the regulatory limits described above with the exception of nitrogenous waste – in particular, ammonia (NH_3) – though noted that all parameters fluctuated widely on a temporal/seasonal basis. Of note, the authors concluded that municipal effluents had a significant impact on the quality of water available to aquaculture, particularly nitrogenous waste generated by a nearby petrochemical plant which dumps waste, under permit from the Environmental Affairs Agency (EEAA), 500 meters offshore. The authors also comment that extremely high nutrient levels experienced in springtime are likely linked to the seasonal drainage of agricultural irrigation water via the Hadus drainage canal, which flows into Lake Manzala (El-Mezayen et al. 2018). This evident conflux of pollutants makes it challenging to disaggregate the causative elements of effluent impacts within the immediate vicinity of fish farms, and further underscore the lack of effective enforcement of effluent discharge quality regulations, as these other polluting industries are regulated by the same laws as aquaculture.

A recent EU-funded project (EU Seventh Framework Programme – FP7 /2007-2013), entitled 'Fisheries and Aquaculture-Oriented Research Capacity in Egypt' (FORCE), has reportedly enhanced collaboration between the EU and Egypt by engaging with the National Institute of

Oceanography and Fisheries (NIOF) plus other Egyptian Institutions. The aim of the project was to support the sustainable development of the fisheries and aquaculture sector using an ecosystem-based approach, which included the development of modelling tools for site selection and environmental impact assessment. A report on the project states that "*FORCE played an important role in building institutional capacity among all partners, stakeholders and contributes to the preparation and development of Environmental Impact Assessment (EIA) and Terms of Reference (TOR) as guide lines for fish farming. This will assist potential investors in choosing appropriate sites and preparing an environmental management plan for the management of their farm, thus helping GAFRD and EEAA in applying innovative systems for follow-up of fish farms impact on surrounding environment*", (FORCE 2013). The report also notes that this project has paved the way for the participation of Egyptian institutions in future European research funding programs and ongoing collaboration. Although this project concluded in 2014, the project website[45] is still available online. The final report on the project describes the success of each deliverable (FORCE 2013) but the longer-term outcomes of this initiative, and its application, are unclear.

Broadly, it is clear that enforcement of effluent regulations in Egypt is insufficient, given the fragmented nature of regulatory jurisdiction and the little evidence of monitoring or compliance data. Despite promising recent developments to increase enforcement effectiveness and capacity, the score for Factor 2.2b – Enforcement of effluent management measures is 1 out of 5. The final score for Factor 2.2 is a combination of Factor 2.2a (1 out of 5) and Factor 2.2b (1 out of 5), which results in a final score of 0.4 out of 10.

Conclusions and final score: Egypt

In conclusion, there is a significant challenge with effluent pollution in Egypt's water bodies and irrigation canals – although agriculture, not aquaculture, is the primary source of these contaminants, since this sector accounts for 95% of Egypt's water use. It is evident that both the content of management measures and their enforcement are ineffective in addressing this issue. Additionally, there is a lack of data available on aquaculture effluents; no studies were identified which robustly addressed the environmental impacts of the sector. The final numerical score for Criterion 2: Egypt – Effluent is 0 out of 10 indicating that waste discharge is high and regulatory control and management is weak, and as such is considered a Critical conservation concern to Seafood Watch.

[45]http://www.forceproject.eu/indexee11.html?option=com_content&view=category&layout=blog&id=95&Itemid=435&lang=en

Criterion 3: Habitat

Impact, unit of sustainability and principle

- Impact: Aquaculture farms can be located in a wide variety of aquatic and terrestrial habitat types and have greatly varying levels of impact to both pristine and previously modified habitats and to the critical "ecosystem services" they provide.
- Sustainability unit: The ability to maintain the critical ecosystem services relevant to the habitat type.
- Principle: being located at sites, scales and intensities that maintain the functionality of ecologically valuable habitats.

Criterion 3 Summary: EU & Turkey

Habitat parameters	Value	Score
F3.1 Habitat conversion and function		7
F3.2a Content of habitat regulations	4	
F3.2b Enforcement of habitat regulations	3	
F3.2 Regulatory or management effectiveness score		5
C3 Habitat Final Score (0-10)		**6**
Critical?	NO	**YELLOW**

Criterion 3 Summary: Egypt

Habitat parameters	Value	Score
F3.1 Habitat conversion and function		4
F3.2a Content of habitat regulations	2	
F3.2b Enforcement of habitat regulations	0	
F3.2 Regulatory or management effectiveness score		0
C3 Habitat Final Score (0-10)		**3**
Critical?	NO	**RED**

Brief Summary

This Criterion has been split into two separate recommendations: one for the EU and Turkey and one for Egypt; this differentiation is required due to significant regional differences in both production systems and legislative framework.

Studies on seabream, seabass and meagre aquaculture taking place in the EU and Turkey demonstrate that the sector has moderate habitat impacts within the immediate footprint of the farm. Two of the most vulnerable habitats present in the water bodies included in the scope are *Posidonia* seagrass meadows and maërl beds and studies reviewing the impact of fish farming activities upon these habitats date back to the 1990s. In 1992 the EU Habitats Directive was enacted to protect these and other identified priority habitats. Subsequently, member states have introduced legislation at the national level to implement the requirements of this directive. In alignment with this EU initiative, Turkey also introduced regulations to ensure farms were not located above these sensitive habitats, in 2006; similar legislation was also passed shortly thereafter in Greece, in 2009. The effectiveness of robust regulation is somewhat limited by moderate enforcement, given the varying levels of capacity and adoption of key environmental indicators, EU Directives, and GFCM resolutions across the sector, resulting in a moderate impact score of 6 out of 10 for Criterion 3: EU & Turkey – Habitat.

There is a lack of data available concerning the habitat impacts of seabass, seabream and meagre production in Egypt, which necessitates a precautionary approach in the scoring of this Criterion. Habitats contiguous to fish farms are clearly adversely affected by anthropogenic impacts, although the primary polluter would appear to be the dominant agriculture sector. There is a scarcity of both freshwater and arable land in Egypt, which means that land is only approved for aquaculture if it is not suitable for agricultural production. Although the importance of environmental management is recognized and broadly addressed in legislation, it is poorly implemented and laws specifically pertaining to aquaculture and the species under assessment are hard to identify. Specific monitoring requirements for aquaculture are lacking. EIAs are theoretically required for some types of aquaculture although this is reportedly seldom enforced. The final numerical score for Criterion 3: Egypt – Habitat - is 3 out of 10.

Justification of Rating

In contrast to the Effluent Criterion, which reviews environmental impacts outside the allowable zone of effect, the Habitat Criterion assesses more proximal impacts within the immediate farm boundary. As stated before, the General Fisheries Commission for the Mediterranean (GFCM) defines the AZE as follows: "*The area of sea-bed or volume of the receiving water body in which the competent authority allow the use of specific Environmental Quality Standard (EQS) for aquaculture, without irreversibly compromising the basic environmental services provided by the ecosystem*," and further clarify that "*The main idea is that within the AZE (i.e. in the immediate vicinity of the farm) some deviation from national and international standards is expected but not beyond a point (threshold) where critical goods and services provided by the marine ecosystem are irreversibly compromised*," (FAO-GFCM 2013). For the purposes of this assessment, the AZE is considered to be the area within 30 m from the net pen edge.

Although the Effluent Criterion focuses on a more distal impact location than the Habitat Criterion, both consider the effects of soluble and particulate wastes emanating from fish farms into their surrounding environment. While soluble wastes can increase nutrient loading in the vicinity of farms, particulate wastes increase deposition of sediments, particularly in coastal waters. Sedimentation and organic loading from fish farms can make benthic communities vulnerable to biochemical changes which can change their composition and function. Since the production systems used in Egypt are notably different to those used by the rest of the producers within the scope, and the availability of data from the region is much less, the Egyptian sector will be assessed separately for this criterion.

Factor 3.1 Habitat conversion and function: EU & Turkey

Cage culture in the EU and Turkey

Multiple studies from the Mediterranean have focused on environmental impacts caused by dispersal of organic waste materials from seabream and seabass farming operations – data specifically pertaining to meagre farming is sparse, however, since this species is a relative newcomer to aquaculture and present production is limited.

Sensitive habitats: seagrass meadows and maërl beds

As has already been mentioned in Criterion 2: EU & Turkey – Effluent, the semi-enclosed Mediterranean Sea is considered to be oligotrophic, meaning that it is naturally deficient in nutrients. Since benthic communities and sediments in this waterbody typically experience a low influx of nutrients and particulate matter from the water column, elevated inputs from fish farming activities can have a significant impact (Sanz-Lázaro & Marín 2008). The Mediterranean also has a low tidal range and experiences the formation of a seasonal thermocline each summer (Sanz-Lázaro and Marín 2008, Grigorakia & Rigos 2011).

The Mediterranean's coastal habitats and shallow reefs host a complex array of extremely biodiverse and productive ecosystems, such as seagrass meadows, mollusc reefs, coralligenous maërl formations, and macroalgal assemblages. Due to the restricted availability of nutrients, such ecosystems are dominated by slow growing species that take a long time to recover if they are disturbed. "*The Mediterranean Sea is considered as one of the 25 hotspots of global biodiversity, hosting 7% of the world's species (4-18% according to the considered phylum) living in 0.82% of the ocean area and 0.28% of the ocean volume. Species diversity in the Black Sea is 3.5 times poorer than in the Mediterranean Sea. This difference reflects the considerably lower salinity in the Black Sea and large volume of anoxic waters*," (Hilmi et al. 2015).

The MedVeg project, which took place between 2001 and 2004 (and discussed previously in Criterion 2: EU & Turkey – Effluent), identified fish farm waste sediments as the primary driver of benthic deterioration in seagrass meadows and a recommendation was made that fish farms should be sited at a distance of at least 400 meters from such sensitive habitats, particularly with reference to *Posidonia oceanica* meadows (Mirto et al. 2010, Diaz-Almela et al. 2008, Holmer 2008). *Posidonia* beds and coralligenous outcrops (under '*1170 Reefs'*[46]) are designated as a 'priority habitat' and protected under the EU's Habitats Directive (Council Directive 92/43/EEC): Article 11 of this legislative act declares that "*Member States shall undertake surveillance of the conservation status of the natural habitats and species*" ... "*with particular regard to priority natural habitat types and priority species,*" (EU 1992). However, as the website of the European Union[47] notes, directives are not legally binding, rather they set out goals for member states, and each nation is ultimately responsible for its own legislation and enforcement with regards to fish farm siting and protection of 'priority habitats'. Writing in 2013, Karakassis opined that: "*There are fears that a large proportion of fish farming activity is*

46

47 https://europa.eu/european-union/eu-law/legal-acts_en#directives

sited above such meadows despite the existing regulations in most Mediterranean countries," further noting that, in 2009, a new regulation was passed in Greece which, amongst other provisions, stipulated that there should be no new farms sited over Posidonia meadows and no expansion, or renewal of concessions, would be granted for farms currently sited in such localities (Karakassis 2013). As a result of this legislation, the majority of farms have reportedly now relocated into deeper water (pers. comm. Nafsika Papageorgiou, October 2019) and any farms that have not relocated are thus automatically phased out as their licenses expire (pers. comm. Nafsika Papageorgiou, March 2020). A recent Cypriot study, which also describes the relocation of farms into deeper waters, due to regulatory amendments disallowing expansion in the vicinity of *P. oceanica* meadows, found that seagrass recovery was already occurring to some extent in areas where farms had previously been sited (Kletou et al. 2018). The most dominant country producers, Greece and Turkey, both implemented the AZA concept over a decade ago, in 2009 and 2006, respectively (AquaSpace 2018a). As a result, and to protect seagrass beds from aquaculture impacts, both countries subsequently passed laws prohibiting fish farming in the vicinity of *P. oceanica* meadows, stipulating that farms must be sited in water depths of 30 m or more, a depth which is on the perimeter of *P. oceanica*'s survival range (pers. comm. Nafsika Papageorgiou, October 2019; Ferit Rad, October 2019). Similarly, under Spanish law, farms must also be sited at least 30 m or more from *P. oceanica* habitats (pers. comm. Nafsika Papageorgiou, October 2019).

<u>Benthic impact studies</u>
As noted above, in order to mitigate against near-shore environmental impacts, fish farming sites in the Mediterranean have been moving further away from coastal areas in recent times. Benthic studies from more exposed farm sites, located farther out to sea, have identified that the impacts of particulate fish waste from such farms are less than those of farms closer to shore, due to the greater dispersal of these products in deeper, more dynamic ocean environments. Writing in 2010, Holmer, noted that "*None of the available studies at off-coast and offshore farms have detected significant nutrient enrichment or effects on the water column, suggesting a rapid dispersal of dissolved compounds or a rapid transfer of waste products to higher trophic levels*". However, she also comments that "*The lack of scientific knowledge on offshore fish, mammal and benthic communities is problematic for the development of offshore mariculture, as cautionary principles have to be applied until sufficient documentation is available*," (Holmer 2010). The results of an off-shore farm complex study in Spain broadly concur with this: using stable isotope analysis to determine if an off-shore farm could still impact near-shore seagrass beds, researchers found that the influence of the farm "*Was not sufficient to produce significant meadow alterations, unlike those described in near shore case studies under a more severe influence of nutrients*". However, they also stated that their results provided "*Consistent evidence that waste delivered by offshore farms has a large area of influence (spanning kilometres) that affects Posidonia oceanica meadows located in remote near shore environments*," (Ruiz et al. 2010).

Aguado-Giménez et al. (2012) conducted a study to assess benthic recovery at an ex-seabream and meagre farm in the Spanish Mediterranean after the abatement of fish farming activity. The study commenced one year before, and ended one year after, farming activity ceased.

Upon completion, researchers concluded that improvements in the benthic geochemical conditions were occurring, indicating a process of recovery that was still on-going. These findings echo those of earlier studies on benthic, non-vegetated systems, in areas that had previously been used for farming seabream and seabass, which also observed the process of recovery, noting that complete recovery took longer than one year (Sanz-Lázaro & Marín 2006, Karakassis et al. 1999).

Regeneration of benthic communities has been effectively accomplished through use of fallowing and rotation practices (Holmer 2010) and is a common procedure in salmon production but this approach is seldom implemented in areas culturing seabass and seabream (Sanz-Lázaro & Marín 2008), apparently due to space constraints (Sanchez-Jerez et al. 2016, Hofherr et al. 2015) and a lack of access to appropriate sites where fallowing can be implemented (AE 2014, IUCN 2009). A multiplicity of businesses exist along the coastal zone of the Mediterranean, especially tourist-related enterprises, and competition for land and ocean use is high; a recent study of the region's aquaculture sector, which specifically considered space constraints, noted that the industry presently occupies around 3% of the coastline in the EU (Hofherr et al. 2015). Although the waters of the Mediterranean Sea are typically calm and benign, the Meltami wind, which blows from mid-May to mid-September, can cause sudden rough seas and strong gales up to force 8 or 9 (TripSavvy 2018), which has no doubt been an inhibiting factor in locating farms farther off-shore in affected areas.

Some studies have used fatty acids as biomarkers to trace the trophic relationships that occur as a result of biotic uptake of wastes dispersed by fish farms. One such study in Spain demonstrated that "*Aquaculture activities have an influence on almost every macroinvertebrate species associated with fish farm sea-cage structures, taking advantage of uneaten feed pellets and faeces*," and concluded that "*The uptake of feed wastes by the macrobenthic fauna might be a beneficial effect, since they reduce its accumulation and use by bacteria, thus preventing the appearance of anoxic zones. Nevertheless, although no negative effects could be detected from this work, the results suggest that better control of aquaculture-derived wastes is necessary to protect the surrounding wild fauna and their feeding behavior*," (Gonzalez-Silvera et al. 2015).

Ninety-six percent of Turkish seabream and seabass production takes place in the Aegean Sea (Yücel-Gier et al. 2009). In this region, a number of studies have been conducted to investigate the impacts that farming of these species has on water column nutrient concentrations and benthic sediments (Basaran et al. 2010, Yücel-Gier et al. 2007, Çinar et al. 2004). The more recent of these studies concluded that: "*Concentrations of physicochemical variables and heavy metals were within the range of tolerable levels for the marine ecosystem, and the oligotrophic nature of the water column in the study area was able to assimilate organic and inorganic loads caused by the fish farms*," (Basaran et al. 2010). These findings were similar to those of another Turkish study that investigated the impact that seabream and seabass farming had on benthic communities in the (south eastern) Black Sea, where 3% of Turkey's production of these species takes place. A total of three cage sites were involved in this project: samples were taken directly underneath the cages and also at numerous locations 50 meters away from them.

While benthic impacts were overall low, seasonal variations were observed; these were partly due to fluctuations in water flow, but impacts were also less evident in summer, when farming activity was at its lowest (Bascinar et al. 2014).

In Macaronesia, Riera et al. (2017) conducted benthic trials using the MACAROMOD modelling tool to examine the benthic impacts of eight offshore seabream, seabass and meagre farms. The researchers found that benthic impacts were minimal and commented that, "*In the present study, fish aggregations played a pivotal role, consuming most of* [the] *uneaten pellets (ca. 97% in the Canaries and 75% in Madeira). These percentages may be explained by the oligotrophic nature of Macaronesian waters, underpinning low fish biomass in coastal environments. Hence, the organic output from offshore cages constitutes a high nutritional and easily accessible food source for fish aggregations*."

One of the findings of the recent AquaSpace project (AquaSpace 2018b) is that Mediterranean aquaculture producers in EU and GFCM countries normally only perform benthic monitoring once every three years, due to the time and costs involved. Overall, however, literature indicates that the functionality of benthic habitats within the AZEs of seabass/bream/meagre farm sites in the EU and Turkey are considered to be maintained but moderately impacted. Although localized impacts under net pens have been identified, the provision of ecosystem services at any one farm site may be relatively rapidly restored through fallowing, and the broader ecosystem functionality appears to be maintained. Of note, producers in Greece, the EU's main producer of the species under consideration, have extensively adopted the routine application of BMPs, including year-class separation, species rotation, and site fallowing (pers. comm. John A. Theodorou, PhD, December 2019). The score for Factor 3.1, as it pertains to the EU and Turkey, is 7 out of 10.

Factor 3.1 Habitat conversion and function: Egypt

<u>Pond culture in Egypt</u>
Factor 3.1 evaluates habitat impacts within the immediate footprint of farms culturing the species under review, taking both current and historical impacts into consideration. Literature which discusses the wider Egyptian aquaculture sector at large notes that there is a dearth of data on this topic in general (Soliman & Yacout 2015; Samy 2015), thus no studies were identified which specifically explored the habitat impacts of culturing seabream, seabass and meagre in Egypt.

As shown in Table 5, Damietta Governorate, which is located in the northeast of the Nile delta on the Mediterranean coast, is where 91% of seabream, seabass and meagre culture takes place, this occurs predominantly in the area known as the Deeba Triangle. Almost all of this production is semi-intensive and is conducted in marine/brackish ponds (GAFRD 2018b). This region is located at the north-western end of Lake Manzala and comprises around 14,000 ha of reclaimed land on which aquaculture ponds have been excavated, as have a number of canals which lead to the ocean (Cataudella et al. 2015). In addition to seawater inlets, ponds receive water from estuary and lake inlets also, in addition to brackish ground water which becomes available as ponds are dug. This land reclamation came about as a result of the construction of the Aswan High Dam in the 1960's (USAID 2000), which impacted the inflow of water into the northern lakes; subsequently, the drought-affected areas were converted to aquaculture and agricultural uses. Note that the salinity of earthen ponds in the Deeba Triangle ranges from 25 ppt up to an extreme of 50 ppt (pers. comm. Dr. Shérif Sadek, December 2019).

Table 5: Production areas and quantities (MT) of Egyptian mariculture in 2016 (exclusive of mullet) - General Authority for Fish Resources Development: 2018 Fish Statistics Year Book (GAFRD 2018b)

Governorate	Seabream	Seabass	Meagre	Shrimp	Total
Damietta	23,224	21,780	16,162	14	61,180
Alexandria	2859	1797			4,656
Ismailia	565	432	-	55	1,052
Port Saied	-	261			261
Fayyoum (cages)		219			219
Others	15	9	-	32	56
Total	**26,663**	**24,498**	**16,162**	**101**	**67,424**

Lake Manzala, like all of the other coastal lagoons, is a shallow water body, with an average depth of between 0.8–1.0 meters (Cataudella et al. 2015). The southernmost part of the Deeba triangle borders Manzala lagoon while the most westerly part lies close to the Mediterranean port town of Damietta; in the east, it stretches toward Port Said (Cataudella et al. 2015). Figure 13 shows the location of Egypt's Mediterranean coastal Lagoons, with Manzala in the middle. Both Bardawil and Burullus lagoons are Ramsar Sites, the former of which was designated in 1988 and the latter in 1998. Of note, aquaculture activities in the vicinity of Burullus, which is a wetland of international importance, have resulted in environmental concerns[48] due to habitat impacts but according to government data, culture of the species under consideration does not take place in this vicinity, as shown in Table 5.

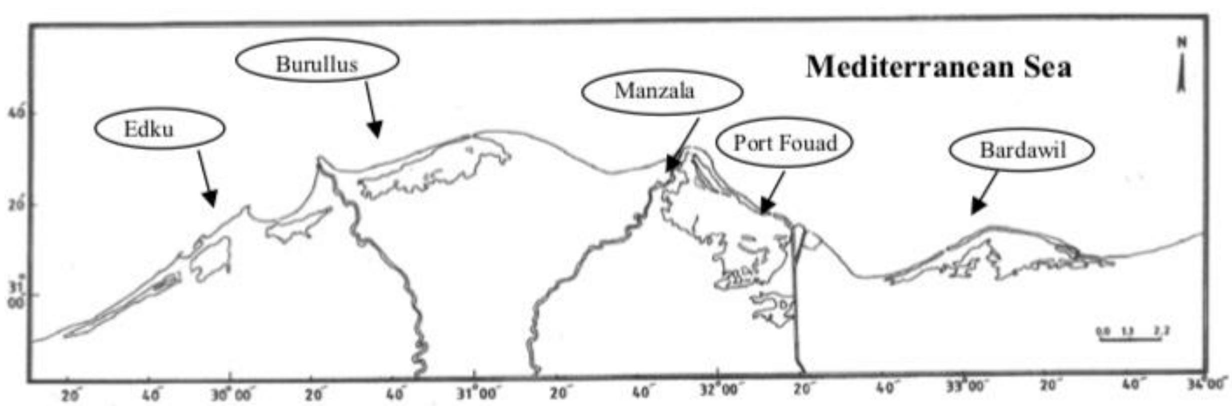


Figure 12: Location of Egypt's Mediterranean coastal lagoons (Cataudella et al. 2015)

[48] https://www.swos-service.eu/2018/06/18/impact-of-aquaculture-expansion-on-lake-burullus/

Although studies on the habitat impacts of seabream, seabass and meagre culture were not identified, it is evident that the sector has expanded significantly in recent years, as is amply demonstrated by its rapid growth trajectory (Shaalan et al. 2017). When FAO Egyptian production volumes of the three species under consideration are aggregated, it is evident that total production of these species has increased more than eight-fold between the years of 2008 and 2017 (FAO 2019). During this time, fish farmers in the Deeba Triangle have facilitated these production increases by consistently and gradually expanding and subdividing ponds, such that around 75% of the area is now used for marine/brackish aquaculture production (El-Mezayen et al. 2018). It is interesting to view this area using the satellite imagery tools available on Google Maps[49], which clearly show the profusion of fish farms in the Damietta region, located in the midst of an extensive zone of heavy industrial, agricultural and urban developments. A small portion of the Deeba Triangle is shown in Figure 14.

Figure 13: Satellite image of the northwestern (seaward) part of the Deeba Triangle, Damietta Governate, Egypt, showing Damietta estuary on the left and a seawater inlet toward the top/center of the image – note that the scale is 1 cm = 200 m (Google Maps 2019)

The fact that many influences, asides from aquaculture, evidently have a significant impact on habitats within the footprint of seabream, seabass and meagre farms in Egypt means that it is challenging to tease out those impacts that specifically pertain to the farms under consideration. This lack of specific data warrants a precautionary approach toward the scoring of this factor – particularly when rapid expansion of the sector over the last decade is taken into consideration. However, this needs to be tempered with the fact that sector growth is occurring in an area that was already converted from high-value wetland around 50 years ago, and the reclaimed land that present-day farms are built on is in the midst of a heavily industrialized zone. The score for Factor 3.1, as it pertains to Egypt, is 4 out of 10, which reflects the present-day moderate value of the coastal delta region in which farming of the species under

[49] https://goo.gl/maps/8nsCo2X5HpP7raLp6

assessment takes place, acknowledging that the loss of functionality as a high-value habitat occurred more than 15 years ago.

Factor 3.2 Farm siting regulation and management effectiveness: EU & Turkey

Scoring for Factor 3.2 is subdivided into Factor 3.2a (content of habitat management measures) and Factor 3.2b (enforcement of habitat management measures).

Factor 3.2a – Content of habitat management measures

Net pen culture in the EU and Turkey: An overview of habitat management measures

The scope of this report includes numerous countries spread across the Mediterranean and Black Sea region, which represent a broad diversity of environmental features and characteristics and varying degrees of aquaculture production and development. This in turn means that the regulatory framework, site selection procedures, and environmental impact assessment (EIA) requirements for aquaculture producers varies somewhat across this large geographical area and between its countries.

As referenced in the introduction to this report, over 84% (per 2017 FAO data) of the aquaculture production under review is produced by four countries: Turkey (35%), Greece (22%), Egypt (20%) and Spain (8%). Of these four nations, Greece and Spain are member states of the EU, whereas Egypt and Turkey are not. However, all producer nations within the scope are members of one organization: the General Fisheries Commission for the Mediterranean (GFCM). Additionally, Regional Sea Conventions (RSCs) are in place to oversee protection of the various water bodies in the region: OSPAR (Convention for the Protection of the Marine Environment in the North-East Atlantic), HELCOM (Convention on the Protection of the Marine Environment in the Baltic Sea), Barcelona Convention (Convention for the Protection of Marine Environment and the Coastal Region of the Mediterranean), and Bucharest Convention (Convention for the Protection of the Black Sea) (Tornero & Hanke 2016).

General Fisheries Commission for the Mediterranean

The GFCM, which is also discussed in Criterion 2 above, is a collaborative forum that was established by FAO in 1948 to facilitate communal management of fisheries resources across the Mediterranean and Black Sea region. Part of its remit is to promote regional dialogue and to facilitate policy coordination and, to this end, the GFCM passed a resolution (Resolution GFCM/36/2012/1) in 2012 concerning guidelines on allocated zones for aquaculture (AZA) which stipulated that all contracting parties "*Shall include in their national marine spatial planning strategy of aquaculture development and management schemes for the identification and allocation of specific zones reserved for aquaculture activities*." Furthermore, the resolution stipulates that for each unique AZA, an allowable zone of effect (AZE) must be defined and a mandatory environmental monitoring program put in place at the national level (GFCM 2012). Adoption of this area-based management approach takes the scale and intensity of aquaculture production into consideration and is intended to support and maintain the ecological functionality of habitats in the proximity of fish farms. The Resolution states that "*AZAs shall be established within the remit of local or national aquaculture plans of CPCs* [Contracting Parties and Cooperating non-contracting Parties of the GFCM] *with the aim of ensuring the* *sustainability of aquaculture development and of promoting equity and resilience of interlinked social and ecological systems*" (GFCM 2012).

Allocated zones for aquaculture (AZA)

As discussed earlier, in Criterion 2: EU & Turkey – Effluent, recent reviews of the sector indicate that the AZA concept that was proposed by GFCM to its members in 2012 has been widely implemented by farms producing seabream, seabass and meagre across the region, albeit with some regional adaptations that take local environmental characteristics into consideration (AquaSpace 2018a, FAO 2018a, FAO-GFCM 2013, Hilmi et al. 2015, Sanchez-Jerez et al. 2016). New regulations were adopted in Turkey in 2007, which saw the establishment of two new AZAs in Gulluk Bay, the county's primary mariculture zone (Aguilar-Manjarrez et al. 2017).

European Union Directives: Environmental Strategies

A high degree of commonality in general legislation is shared by producers whose aquaculture facilities lie within the jurisdiction of the European Union (EU). The EU has adopted many overarching resolutions and directives that are specific to the aquaculture sector (European Parliament 2018); the two main legal instruments that pertain to management measures within the AZE of seabream, seabass and meagre farms are the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) (EEA 2018, EC 2016). The purpose of the WFD (Directive 2000/60/EC) is to keep inland and coastal waters clean by controlling the input of nutrients and chemicals, whereas the MSFD (Directive 2008/56/EC) aims to make the seas 'clean, healthy and productive', requiring that member states develop strategies to achieve 'good environmental status' in their marine waters by 2020 and these strategies must be developed around the following eleven 'descriptors':

- Biodiversity is maintained
- Non-indigenous species do not adversely alter the ecosystem
- The population of commercial fish species is healthy
- Elements of food webs ensure long-term abundance and reproduction
- Eutrophication is minimised
- The sea floor integrity ensures functioning of the ecosystem
- Permanent alteration of hydrographical conditions does not adversely affect the ecosystem
- Concentrations of contaminants give no effects
- Contaminants in seafood are below safe levels
- Marine litter does not cause harm
- Introduction of energy (including underwater noise) does not adversely affect the ecosystem

In 2014, the Maritime Spatial Planning (MSP) Directive (Directive 2014/89/EU) was introduced. This Directive, which is the primary legislative instrument concerned with establishing a framework for maritime spatial planning, has already been adopted by some member states but must be implemented by all of them by 2021 (EU 2014b). The MSP Directive applies to aquaculture facilities which are over one nautical mile from the shore (AquaSpace 2018b).

The progress of member states toward achievement of these environmental strategies is reviewed every six years and, applying an adaptive management approach, the Marine Strategies themselves are reviewed and updated on this cyclical basis to ensure that targets are being met (EC 2019, EC 2018a). Since the MSFD applies to marine waters that are over one nautical mile from the shore – whereas the WFD applies to near-shore waters - this means that the MSFD is becoming of greater relevance to aquaculture as the industry moves further offshore (EU 2009a).

The Environmental Impact Assessment (EIA) Directive, which was adopted into the EU legislative framework in 1985, is another governance instrument that is relevant to the aquaculture sector, although EIAs are not always mandatory. Extensive guidance and checklists to enable countries to decide whether an EIA is necessary or not is provided by the EU, and details of this process must be documented and be available for public inspection if requested. If an EIA is deemed necessary, guidelines for scoping and EIA report preparation are also provided by the EU (EU 2017). This means that EU member states ultimately set their own criteria and thresholds for the conditions that trigger requirement of an EIA, although these thresholds are guided by the EU's screening guidelines. For example, the thresholds for Greece and Spain are as follows (EC 2009):

Greece

- All fish hatcheries when not located in AZA
- Marine fish farms not located in AZA
- Marine fish farms located in AZA and in NATURA 2000 areas[50]
- Marine fish farms located in AZA but not in NATURA 2000 areas and ≥ 500 tons/year
- Shellfish farms not located in AZA
- Shellfish farms located in AZA and ≥ 200 tons/year
- Freshwater farms located in NATURA 2000 areas
- Freshwater farms ≥ 200 tons/year and not located in NATURA 2000 areas
- Technologies and types of aquaculture appearing for first time
- Protected species
- Alien species

In cases that EIA is not needed, farms instead issue and submit for approval a "Letter of Commitment to Environmental Norms".

[50] NATURA 2000 areas: Stretching over 18% of the EU's land area and almost 6% of its marine territory, it is the largest coordinated network of protected areas in the world. It offers a haven to Europe's most valuable and threatened species and habitats (http://ec.europa.eu/environment/nature/natura2000/indexen.htm)

Spain

- 500 MT production/year (national requirement; regional governments can require EIA also below this threshold).
- Also for <500 MT production/year in Natura 2000. Always to designate allocated zones for aquaculture.

Turkey

In Turkey, the main authority which issues permits for new marine cage farms is the Ministry of Agriculture and Forestry (previously named the Ministry of Agriculture and Rural Affairs). Turkey has integrated many adaptations of EU directives into governance of its aquaculture sector and one such instance of this was implementation of the EIA process (Yücel-Gier et al. 2009). As per Article 8 of Aquaculture Regulation No. 25507, aquaculture entities which have an annual production capacity in excess of 1000 MT must be compliant with the Regulation of Environmental Impact Assessment (EIA) No. 26939 before a new operations license can be granted. In instances where a farm's production capacity is 30 MT or less, no EIA is required, whereas farms with a capacity between 30-1000 MT are assessed on a case-by-case basis. This assessment, and any subsequent EIA review, is conducted by the Directorate General for EIA which resides within the Ministry of Environment and Urban Planning (FAO 2005-2018a). The legal, regulatory and institutional frameworks applicable to Turkish marine aquaculture are summarized in Figure 15.

Law	Content
Fishery Law (Fishery Law No. 1380, 1971) and its amendment (Fishery Law No. 3288, 1986; Fishery Law No. 4950, 2003).	All fisheries and aquaculture activities are regulated by the Fishery Law. With the last revision (2003) important legislative principles and standards were provided for the establishment and management of aquaculture facilities.
Environmental Law (Environmental Law No. 2872, 1983) and its amendment (Environmental Law No. 5491 in 2006).	Its associated regulations laid the general legal basis and framework for environmental protection similar to many other European countries. The last Turkish Environmental Law (2006) forced marine aquaculture facilities to move offshore within one year.
Regulation	**Content**
Regulation on Aquaculture (No. 25507) in 2004 (MARA, 2004), as amended in 2005 (MARA, 2005 and 2006).	It addressed major issues related to aquaculture like license renewal and development in terms of management, technology and related matters. A minimum capacity of 250 tonnes/year and water quality criteria were fundamental considerations in these proposed licensing requirements for marine aquaculture.
In 1993, detailed EIA regulations were enacted; these regulations were again extended and revised in 1997, 2002, 2003, 2008 and finally in 2013. They accommodated adaptations in accordance with the European Union EIA Directives 85/337/EC and 97/11/EC.	A major component of this regulation regarding aquaculture activities is the need for the Environmental Impact Assessment (EIA). This is a process to define the environmental alterations that any developmental projects may have and, subsequently, to determine whether a project can be approved, or needs to be amended before approval, or rejection. EIA only applies to 1,000 tonne/year capacity farms.
Regulation for Water Pollution Control (MEF, 2004) were revised in 2008 (MEF, 2008)	Also, according to the Regulation for Water Pollution Control, Article 15 gives the general criteria of quality required for marine environments.
In 2007 a regulation (MEF, 2007) was made to identify the criteria for closed bays and gulfs qualifying as sensitive areas where fish farms are not allowed.	Fish farms already established in enclosed bays and sensitive areas were to be reevaluated in accordance with physical and chemical criteria.

Figure 15: Legal, regulatory and institutional frameworks applicable to Turkish marine aquaculture (Aguilar-Manjarrez et al. 2017)

Broadly, the above management measures are considered to be robust, as cumulative aquaculture farm siting is based on maintaining ecosystem functionality and operates at the area level. The assessed score for 3.2a (content of habitat management measures) for the EU & Turkey is 4 out of 5.

Factor 3.2b - Enforcement of habitat management measures

The recent, EU-funded AquaSpace project (AquaSpace 2018b) included a review of the efficacy of management measures governing aquaculture in the Mediterranean (both EU and GFCM countries) within its remit: the study analyzed the laws, degrees and policies that govern the sector across the region. Researchers found that the legal framework governing the sector was generally overly bureaucratic, confusing and complex, and that often the designation of responsibility between authorities was unclear due to an overlapping of procedures. For example, it was found that in 40% of the countries reviewed, more than seven different regulatory authorities were involved in the process of aquaculture licensing. Furthermore, it was found that the greater the number of authorities involved, the less efficient the co-ordination of the process was likely to be. Of particular note, and with regard to the main seabream, seabass and meagre producers in the region, Turkey, Greece, Spain and France have in place 15, 11, 10, and 12 such authorities, respectively (AquaSpace 2018b).

Implementation of EU Directives that govern aquaculture is delegated to the Competent Authority of each EU member state, which in turn is responsible for the oversight and enforcement of these habitat management measures within their respective countries. The need to streamline the regulatory framework that governs the aquaculture sector has long been recognized within the EU and GFCM countries and numerous projects and initiatives have contributed toward realization of this goal. In 2009, the IUCN highlighted the "*Lack of an appropriate legal framework that promotes the aquaculture industry*," in the Mediterranean (IUCN 2009) and now, nearly a decade later, this sentiment still prevails: the European Parliament's resolution on aquaculture, dated 12 June 2018, states, "*Whereas EU environmental legislation is based on directives (the Marine Strategy Directive, the Birds and Habitats Directives), and whereas it is therefore left to Member States and to local and regional authorities to transpose and apply them with a certain degree of discretion; whereas, consequently, there is no uniform implementation throughout the EU and this leads to legal uncertainty for enterprises and farms and a lack of predictability for investors, and creates an uneven playing field*," (EU 2018a).

The AquaSpace project found that while the sector had made good progress in recent years in improving environmental management of the sector, some specific concerns with regards to environmental monitoring were apparent (these pertained not only to the EU but also to other producing countries covered in the review):

- *In a number of countries although monitoring is incorporated in the regulations no specific monitoring guidelines are given,*
- *There is a lack of a uniform monitoring system, with thresholds calibrated for the different areas,*

- *Benthic monitoring, as conducted, is costly and time consuming and consequently is not done very often (normally once every three years)*

In conclusion, countries producing seabream, seabass and meagre within the EU and Turkey have identifiable and active organizations in place to administer the habitat management measures that govern the sector. However, it is clear that ongoing concerns exist with regards to the effective enforcement of such measures due to a lack of common criteria and environmental indicators across the region, resulting in some monitoring gaps and limitations in the implementation of the EU Directives and GFCM resolutions. Until all producers in the sector have completely implemented all Directives and guidelines these concerns will continue, and furthermore, cumulative habitat impacts may not be fully addressed.

As it pertains to the EU & Turkey, the score for 3.2a (content of habitat management measures) is 4 out of 5 whereas Factor 3.2b (enforcement of habitat management measures) receives a moderate score of 3 out of 5. When the scores for these two factors are combined (i.e. [(3.2a x 3.2b) / 2.5] to give a score in the range 0 - 10), the final Factor 3.2 management score is 4.8 out of 10.

Factor 3.2 Farm siting regulation and management effectiveness: Egypt
Scoring for Factor 3.2 is subdivided into Factor 3.2a (content of habitat management measures) and Factor 3.2b (enforcement of habitat management measures).

<u>Factor 3.2a – Content of habitat management measures</u>

<u>Aquaculture in Egypt: An overview of habitat management measures</u>
The FAOs FAOLEX (2019a) database on national legislation, policies and agreements provides access to the laws, acts, decrees and resolutions that pertain to Egyptian aquaculture. In reviewing these legal provisions, it is evident that little has changed with regard to specific regulation of the Egyptian aquaculture sector in several decades, despite its dramatic growth during this time. The main statutes that pertain to the sector, and the agencies responsible for their implementation, are explored in further detail below.

The Ministry of Agriculture and Land Reclamation (MoALR) is the government agency which has overall responsibility for the development of policies governing agriculture, aquaculture and land reclamation, and they must perform these functions in accordance with national development plans. The main legislative instruments of MoALR are Law No. 53 of 1966[51] and Resolution No. 162 of 1996 (Goulding & Kamel 2013). With relevance to aquaculture, three principle agencies are housed under MoALR to facilitate regulation of the sector, these are: the General Authority for Fishery Resources Development (GAFRD), the General Organization for Veterinary Services (GOVS), and the Agricultural Research Center (including the Central Laboratory for Aquaculture Research (CLAR)). Egypt's basic fisheries law, which is contained

---

[51] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC153081

within Law No. 124 of 1983[52] on Fishing, Aquatic Life and the Regulation for Fish Farms, designates GAFRD as the agency responsible for administering the provisions of this law. Thus, GAFRD is the main authority that controls and monitors the activities of fish farms and the fisheries sector, including environmental monitoring, farm licensing, aquaculture land use regulations, as well as extension and research service. GAFRD is headquartered in Cairo but also has numerous branch offices in the main regions that have fisheries related industries, including Damietta.

As well as designating GAFRD as the principle administrator of Law No. 124 of 1983, this piece of legislation is also the primary act that guides the activities of GAFRD. This law is divided into three sections that are comprised of 65 articles; the first section pertains to general provisions, the second to water pollution, and the third to aquatic resources and the regulation of fish farms. In this legislation, agriculture is prioritized over aquaculture such that article 48 of Law No. 124 of 1983 forbids the construction of fish farms in areas that are suitable for agriculture, thus fish farms are only allowed to be constructed on land that is infertile. This law further states that fish farms can only be established once a license has been obtained from GAFRD, and this in turn is contingent upon the approval of the Ministry of Water Resources and Irrigation (MoWRI), in that a permit specifying the quantity and source of water for fish farms, plus the method of drainage and other conditions of use, must be granted by this agency before GAFRD can issue a license; this permitting process is reviewed on a case by case basis. MoWRI is responsible for administering the two main acts that deal with water resources: these are Law No. 12 of 1984[53] and Law No. 48 of 1982[54]. Law No. 12 of 1984 is concerned with the right of access to water for agricultural landowners, including aquaculture, however, this law applies to inland waters only. Law No. 48 of 1982 is concerned with the protection of the River Nile from pollution and the license conditions which need to be met in order to obtain a discharge license that allows wastes to be discharged into canals. Governance pertaining to fish farms that are reliant on groundwater, such as those in the Deeba Triangle, is absent in legislation (Goulding & Kamel 2013).

MoALR, as previously mentioned, is the government agency which has overall responsibility for the development and control of policies governing agricultural and aquacultural land use in Egypt. Under the authority of MoALR, and as defined in Presidential Decree No. 465 of 1983, GAFRD are authorized to lease land that is within 200 m of the shoreline to fisheries and aquaculture related enterprises. However, only land which has been designated for aquaculture (and is not suitable for agriculture) may be leased; the designation of land on which aquaculture is permissible is the responsibility of a GAFRD committee, who in turn make such land allocations in accordance with Decision No. 70 of 1986[55] (Goulding & Kamel 2013).

[52] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC018648/
[53] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC121428
[54] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC018642
[55] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC070574

As discussed in Criterion 2 – Effluent, Laws pertaining to environmental policy lie within the jurisdiction of the Ministry of Environmental Affairs and the Egyptian Environmental Affairs Agency (EEAA), which is housed under this ministry, is responsible for the implementation and monitoring of these policies. The main environmental act is Law No. 4 of 1994[56], which was later amended by Law No. 9 of 2009[57]; this legislation prohibits the discharge of pollutants into ocean and inland waters – from any source - unless a license is obtained, and such a license can only be approved by the EEAA upon successful completion of an EIA. License holders must conduct self-monitoring pertaining to the wastes that they discharge and are subject to periodic inspections by the Ministry of Environmental Affairs. This law is not specific to fish farming but is applicable to the environmental governance of all industries (Goulding & Kamel 2013). Although EIA requirements are in place for marine aquaculture, this procedure reportedly seldom applies to inland aquaculture (Soliman & Yacout 2016). The most recent 'Fish Statistics Year Book' published by GAFRD (2018b) notes that production of seabream, seabass and meagre is almost exclusively conducted in brackish ponds, which in effect means that EIA is typically not required for cultivation of these species since it takes place in inland brackish water environments and not in open water marine environments (FAO 2009). Thus, although the aforementioned legislation is in place, the vast majority of farms culturing seabream, seabass and meagre are constructed without an EIA being required, since they are located in the Nile delta. However, it should be noted that there are a few farms culturing these species in national parks (El-Rayan depression lake in El-Fayum governorate and Nabq, South Sinai) and also on the Egyptian Red Sea coast, where an EIA is a requirement (pers. comm. Dr. Shérif Sadek, December 2019), although these localities only account for around 2% of current production volumes (see Table 5).

In light of the regulations described here, no information could be found describing the extent to which environmental factors regarding habitat conversion (beyond those governing water pollution from discharges, more directly covered in Criterion 2 – Effluent) are considered in the site licensing process, and thus the content of these management measures is considered to be limited. The score for 3.2a (content of habitat management measures) in Egypt is 2 out of 5.

Factor 3.2b - Enforcement of habitat management measures

A recent review of aquaculture in GFCM countries concurs that, in the Egyptian sector, EIAs are typically not required and that the country lacks a monitoring program for the industry (AquaSpace 2018b). Of additional note, a recent review of the sector by WorldFish notes that: "*There is a clear lack of coherence in Egypt's state policy towards the aquaculture sector*," and "*Aquaculture operators utilizing seawater, or groundwater, or using marine cage production*

[56] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC004984/
[57] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC152133/

operate without a clear legal basis," ... "*Furthermore, the lack of a coherent strategy across different Ministries has resulted in a long list of license and permit requirements requiring separate approvals of multiple competent authorities. As a result, unlicensed fish farms constitute nearly 60% of the sector*," (Goulding & Kamel 2013). This lack of effective legislation and monitoring requirements for the aquaculture sector is echoed by other authors also (Shaalan et al. 2017, FAO 2017b, Samy 2015, Sadek 2013), as is the lack of studies on the environmental impacts of the sector (Soliman & Yacout 2015). Soliman & Yacout (2016) comment that although the hosha farming technique is banned, it still continues illegally to some extent. This traditional extensive production system, which involves making a mud pond at the edge of a lake and allowing wild fish to enter, is reportedly mainly used to grow out tilapia, although seabream, seabass and meagre are sometimes no doubt included amongst the influx of wild species. For the purposes of this assessment, this practice is not considered within the scope of production for seabream, seabass, and meagre in earthen ponds in Egypt, though it does shed some light on the enforcement effectiveness of the governing bodies of the sectors.

As it pertains to Egypt, the score for 3.2a (content of habitat management measures) is 2 out of 5, which reflects the limited nature of habitat management measures that are in place. Due to minimal evidence of monitoring or compliance data, compounded with limited evidence of penalties for infringements, plus the apparent continuation of persistent illegal siting activities, the score for Factor 3.2b (enforcement of habitat management measures) is 0 out of 5. When the scores for these two factors are combined (i.e. [(3.2a x 3.2b) / 2.5] to give a score in the range 0 - 10), the final Factor 3.2 management score is 0 out of 10.

Conclusions and final score: EU & Turkey

The final score for the Habitat Criterion combines the habitat conversion score (Factor 3.1) with the effectiveness of the management or regulatory system to deal with potential cumulative habitat impacts (Factor 3.2). Studies on seabream, seabass and meagre aquaculture taking place in the EU and Turkey demonstrate that the sector has moderate habitat impacts within the immediate footprint of the farm. Two of the most vulnerable habitats present in the water bodies included in the scope are *Posidonia* seagrass meadows and maërl beds and studies reviewing the impact of fish farming activities upon these habitats date back to the 1990's. In 1992 the EU Habitats Directive was enacted to protect these and other identified priority habitats. Subsequently, member states have introduced legislation at the national level to implement the requirements of this directive. In alignment with this EU initiative, Turkey also introduced regulations to ensure farms were not located above these sensitive habitats, in 2006; similar legislation was also passed shortly thereafter in Greece, in 2009. The effectiveness of robust regulation is somewhat limited by moderate enforcement, given the varying levels of capacity and adoption of key environmental indicators, EU Directives, and GFCM resolutions across the sector. The final numerical score for Criterion 3: EU & Turkey – Habitat - is 6 out of 10, indicating that Mediterranean seabass/seabream/meagre farming has moderate habitat concerns in this region.

Conclusions and final score: Egypt

A lack of data pertaining to the habitat impacts of seabass, seabream and meagre farms in Egypt meant that a precautionary approach was adopted in the evaluation of this Criterion. While habitats adjacent to fish farms are clearly negatively impacted by a range of anthropogenic activities, the primary polluter would appear to be the dominant agriculture sector. There is a scarcity of both freshwater and arable land in Egypt, which means that land is only approved for aquaculture if it is not suitable for agricultural production. Although the importance of environmental management is recognized and broadly addressed in legislation, it is poorly implemented and laws specifically pertaining to aquaculture and the species under assessment are hard to identify. Specific monitoring requirements for aquaculture are lacking. In theory, EIAs are required for some types of aquaculture, although this is reportedly seldom enforced. The final numerical score for Criterion 3: Egypt – Habitat - is 2.67 out of 10 indicating that the content and enforcement of aquaculture habitat management measures in this region are a cause for concern.

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

- Impact: Improper use of chemical treatments impacts non-target organisms and leads to production losses and human health concerns due to the development of chemical-resistant organisms.
- Sustainability unit: non-target organisms in the local or regional environment, presence of pathogens or parasites resistant to important treatments
- Principle: limiting the type, frequency of use, total use, or discharge of chemicals to levels representing a low risk of impact to non-target organisms.

Criterion 4 Summary: EU

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	**3**	
Critical?	NO	**RED**

Criterion 4 Summary: Turkey

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	**1**	
Critical?	NO	**RED**

Criterion 4 Summary: Egypt

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	**0**	
Critical?	NO	**RED**

Brief Summary

Due to the regional differences highlighted in this production parameter review on chemical use, three separate scores have been assessed: one for the EU, one for Turkey, and one for Egypt.

In general, the regulatory framework that is in place to govern drug use by the aquaculture sector in the EU and Turkey would appear to be somewhat effective in limiting the use of antibiotics due to the requirement for veterinary prescriptions, though chemicals that are highly and critically important to human medicine are approved for use in both jurisdictions. Although some evidence of resistance to antibiotic treatments have been documented in studies of Mediterranean farmed seabass and seabream, these studies do not attribute this situation to misuse of antibiotics by the aquaculture sector, per se, but note that there are an array of contributory anthropogenic factors. In recent years it has become mandatory in most EU member states to report the quantities and types of antibiotics used in food-animal production to the centralized European Medicines Agency and, in Turkey, veterinarians must make their prescription records available for inspection when requested. New EU legislation has also mandated that farm-level details of antibiotic use must be reported, with a phase-in period commencing in 2022 – although data concerning sector-specific usage is not publicly available at the present time in either the EU or Turkey. Communications with veterinary professionals within the sector, both in the EU and Turkey, suggest that antibiotic use in the sector has reduced significantly in recent years, commensurate with the increased availability and routine application of effective vaccines by seabass, seabream and meager farmers, with close to 100% of stocks reportedly being vaccinated against several bacterial diseases. Antibiotic use data for fish are available in the EU, but not disaggregated at the species level, thus specific usage data for the seabass, seabream and meagre sector are unknown. While communication with some industry veterinarians have indicated that antibiotics are typically used less than once per cycle, additional information suggests that antibiotic use is common in Greece (>50% of total EU production), with no quantification of treatment frequency beyond a minority of the industry exceeding 3 treatments per cycle. Further information indicates that critically-important antimicrobials for human medicine were used in 6% of all antibiotic treatments in Greece in 2019 (a decrease from 30% in 2017), though again, total volume and number of treatments are unknown. No such quantifications of antibiotic use in Turkey could be ascertained.

Overall, despite increased vaccinations and indications from veterinary professionals that antibiotics are typically used less than once per production cycle, additional data indicate that the use of antibiotics in Greece, the major EU producer country, is common and at times, frequent (>3 treatments per cycle). Given the available data and uncertainty in treatment frequency, it is considered that highly important antimicrobials are being used in unknown quantities in the EU, and critically important antimicrobials are being used in unknown quantities in Turkey. In addition, parasiticides such as formalin are in use in both sectors, with no indication of the treatment volumes or frequency able to be ascertained. Net pens are an inherently open production system that allow the discharge of active chemicals, and therefore, an intermediate score is warranted for each sector. The difference in the scores between the EU and Turkey are driven by the unknown usage patterns of different antimicrobials, greater data availability in the EU, as well as more stringent regulatory control in the EU. The final score for Criterion 4 – Chemicals: EU is 3 out of 10, whereas the final score for Criterion 4 – Chemicals: Turkey is 1 out of 10.

Data on the Egyptian sector suggests that there is a lack of regulatory control concerning chemical use by producers of the species under consideration and this necessitates that a precautionary approach is used to score this Criterion. This method of evaluation is further supported by data which demonstrates the development of antibiotic resistant pathogens within the aquaculture sector at large; this includes the usage of chemicals which are critically important to human health, which appear to be being used in unknown quantities. The final score for Criterion 4 – Chemicals in Egypt is 0 out of 10.

Justification of Rating

A wide variety of veterinary medicinal products (VMPs) and other chemicals may be used by fish farmers during the production cycle. Aquaculture VMPs that are typically highlighted as potentially being of most ecological concern are antibiotics (used to combat bacterial disease), antiparasitic VMPs or biocides (used to control parasites), and chemical antifoulant products (used to minimize biofouling) (Guardiola et al., 2012). A recent report published by the European Environment Agency, which studied trends in European aquaculture, noted that there is little data available concerning the impact of chemicals discharged by the industry (EEA 2018). A recent review (Tornero & Hanke 2016), which examined general, sea-based sources of chemical contaminants in European seas, identified numerous individual pollutants which were divided into three separate classes as follows: 22 antifouling biocides, 32 aquaculture medicinal products, plus 34 warfare agents. The 14 medicinal chemicals that the report identifies as being approved for marine aquaculture in the EU are shown in Table 6, these are comprised of: seven antibiotics, one bactericide, four parasiticides, plus one disinfectant and one antiseptic (note that although Sarafloxacin is included in this list, it is not currently a VMP used in the EU according to ESVAC data (ESVAC 2019); ESVAC reports are discussed in more detail below). Three of these antibiotics are listed as critically important for human medicine (flumequine, amoxicillin and oxolinic acid) by the World Health Organization (WHO) and three as highly important (sulfadiazine:trimethoprim, oxytetracycline and florfenicol) (WHO 2019). In addition to the names of these approved VMPs, Table 6 also shows their typical dosage rates and environmental toxicity concerns.

Table 6: Substances used in VMPs approved for marine aquaculture in the EU and their typical dosage rates and toxicity concerns (adapted from Tornero & Hanke 2016, supplementary data – Table S2)

Substance	Remarks on usage and toxicity
	Antibiotics
Amoxicillin	Used in aquaculture for many years in Japan and in the UK since 1990. Used in other European countries like Italy. **Typical dosage in aquaculture is 80-160 mg active ingredient/kg fish day, for a standard period of 10 days**. Very limited studies available on its pharmacokinetics and residue depletion. Not effective against vibriosis and motile aeromonads are inherently resistant. Because of this and its relatively high cost, is **rarely used now in aquaculture** (GESAMP 1997; Marine Institute for SWRBD, 2007). Very short environmental half-life (hours). **Environmental concerns with respect to persistence of the β-lactam group of antibiotics are minimal** (Armstrong et al., 2005).
Florfenicol	Authorized in many countries for use in aquaculture, including Japan, Canada, Norway and UK. **Typical dosage is 10-30 mg active ingredient/kg fish day, usually 10 days**. **Not known to be significantly bioaccumulated** (Marine Institute for SWRBD, 2007). **Degrades rapidly in the sediment with a half-life of 4.5 days and displays low toxicity to aquatic organisms** (Marine Institute for SWRBD, 2007; Ferreira et al., 2007). However, it **presents a serious environmental concern in terms of induction of resistance** (Armstrong et al., 2005). **Moreover, recent research suggests that water-borne pharmaceutical mixtures as low as ng/L levels may still have potential risks to aquatic life** (Lai et al., 2009). **Despite their wide use, its toxicity to marine algae and invertebrates has been scarcely investigated and the need for more studies on long-term and mixture effects has been pointed out** (Ferreira et al., 2007).
Flumequine	Widely used in aquaculture in Europe, Japan and other countries in Asia and Latin America. **Typical dosage is 1 g/100 kg fish day, for 10 days**. Potential to accumulate in aquatic environments (Armstrong et al., 2005). **High efficacy and relatively low toxicity** (Armstrong et al., 2005). Research studies suggest that, apart from peak concentrations following treatments,

	the chronic presence of flumequine in sediments inside and outside farms must be considered (Lalumera et al., 2004).
Oxolinic acid	Widely used in Europe, Japan and other countries in Asia and Latin America. **Typical dosage is 1 g/100 kg fish day, for 10 days**. **Potential to accumulate in aquatic environments**. High efficacy and **relatively low toxicity** (Armstrong et al., 2005). **Found to be very persistent in sediments.** In the deeper layer of the sediment hardly any degradation occurred after 180 days and a calculated half-life of more than 300 days was estimated. The residues in the top layer of the sediment disappeared more rapidly (OSPAR, 2009).
Oxytetracycline	Probably the most widely used antibiotic in aquaculture. **Typical dosage is 50-125 mg active ingredient/kg fish day, for a 4–10 day treatment period**. The ultimate sink for this compound seems to be in dissolved and particle-associated phases in the water column (Armstrong et al., 2005). It **can persist for relatively long periods in sediments** (half-lives in marine sediments were found to be 151 days in the top layer, 0-1 cm, and more than 300 days at 5-7 cm deep). It also persists in fish tissues. It has a low bioavailability when administered orally and immunosuppressive effects on fish and may cause liver damage. Furthermore, a **high incidence of bacterial resistance has been observed**. For these reasons it has being increasingly replaced by other drugs (Fisheries and Oceans Canada, 2003; Ferreira et al., 2007).
Sarafloxacin (note, this is not identified as a VMP in use in the EU in ESVAC reports)	Widely used in Europe, Japan and other countries in Asia and Latin America. **Typical dosage is 10 mg active ingredient/kg fish day, for a period of 5 days**. **Very persistent in sediments** with half-life higher than 80 days. Rapidly photodegraded in water with half-life <1h. Assigned to the 'highest risk' category with respect to the relative potential for veterinary medicines to cause harm (Boxall et al., 2002).
Sulfadiazine	**Typical dose for sulfadiazine: trimethoprim (in a 5:1 ratio) is 30-75 mg/kg, for 5–10 days**. **The environmental implications of release of this type of antibiotic into the environment are unknown** (Armstrong et al., 2005). However, given its broad spectrum and the fact that may be degraded slowly, **it may affect bacteria of the marine sediments and fish pathogens selecting for resistance** (Burridge et al., 2010). It is more persistent than trimethoprim, with which it is commonly combined (Marine Institute for SWRBD, 2007).
Trimethoprim	One of the most widely used antibiotics in aquaculture (synergistically in combination with sulphonamides). **Typical dose for sulfadiazine: trimethoprim (in a 5:1 ratio) is 30-75 mg/kg d, for 5-10 days**. **The environmental implications of release of this type of antibiotic into the environment are unknown** (Armstrong et al., 2005). However, given its broad spectrum and the fact that may be degraded slowly, **it may affect bacteria of the marine sediments and fish pathogens selecting for resistance** (Burridge et al., 2010).
Bactericides	
Bronopol	The European Agency for Evaluation of Medicinal Products (EMEA) enrols bronopol as a safe chemical for aquaculture and it has been used in European countries. **Typical dosage in aquaculture is 50-500 mg/L. It is moderately to highly toxic to estuarine/marine invertebrates and slightly toxic to estuarine/marine fish**. It **undergoes rapid hydrolysis and biodegradation**, which could explain its absence in environmental samples (Remberger et al., 2006).
Parasiticides-Bath treatment	
Azamethiphos	Used in the UK. **Typical dosage in aquaculture is 0.1-0.2 mg/L for 60 minutes**. Unlikely to accumulate in tissues (Fisheries and Oceans Canada, 2003) or in sediments (Haya et al., 2005). It decomposes by hydrolysis in natural water with a half-life of 8.9 days. **Dispersion studies indicated that after release of an experimental treatment, the concentration was below detection (0.1 µg/L) in a short period of time (hours)** (Burridge et al., 2014). **Highly toxic to crustaceans and many marine invertebrates; its effects on fish are less well characterized** (PAN pesticide database[58]). **No negative effect on survival of non-target organisms** except when held within the treatment cage (Burridge et al., 2010).

[58] http://www.pesticideinfo.org

Cypermethrin	Applied in Europe, relatively more often in countries like Scotland. **Typical dosage in aquaculture is 5 µg/L for 60 minutes**. Weakly antiestrogenic and antiandrogenic. It **may degrade to produce oestrogenic residues** (Costello et al., 2001). Unlikely to be accumulated to a significant degree in fish and aquatic food chains since it is rapidly metabolized. However, it **can persist in sediments for weeks and may be desorbed and affect benthic invertebrates**. Large amount of ecotoxicological data for freshwater environments, but **limited knowledge for marine species. Field studies indicated that it is lethal to lobsters and some planktonic crustaceans, but not to mussels, sea urchins or planktonic copepods** (Haya et al., 2005). Although it showed an immediately reduction of plankton density and diversity in lab studies, **in open systems concentrations are expected to drop quickly** and that plankton migration and immigration would lead to recovery of the community (Burridge et al., 2010).
Parasiticides-In-feed additives	
Emamectin benzoate	Widely used. **Typical dosage in aquaculture is 0.05 mg active ingredient/kg fish day for 7 days. Moderate to high bioaccumulation potential** (Telfer et al., 2006). Likely to be rapidly bound to particulate material or surfaces, so **potential impacts could be predicted on sediment dwellers or fauna which feed on suspended particulate material, such as filter feeders. However, no evidence of toxic impacts on organisms in either water column or sediments around fish farm cages after treatment was found** (Telfer et al., 2006). Induces molting in lobsters (Fisheries and Oceans Canada, 2003). Feeding to Atlantic salmon at up to ten times the recommended treatment dose resulted in no mortality. However, signs of toxicity, lethargy, dark coloration and lack of appetite were observed at the highest treatment concentration (Haya et al., 2005). Sort-term exposure can impact biological processes in spot prawn (*Pandalus platyceros*) (Veldhoen et al., 2012**). Based on the current state of knowledge and monitoring requirements, it has the highest risk quotient because of the very low PNEC (Predicted environmental concentrations), but measured concentrations in sediments close to the farm indicate a much smaller localised risk** (OSPAR, 2009).
Teflubenzuron	Apparently no longer produced as an anti-louse treatment. **Typical dosage in aquaculture is 10 mg active ingredient/kg fish day, for 7 days or 2-3 mg active ingredient/kg fish day, for 14 days. Around 90% of the ingested teflubenzuron is evacuated from fish via faeces in the period immediately following treatment, with the remainder entering the environment in the form of uneaten waste feed** (Méndez, 2006). **Few marine studies suggest that sediment is a significant sink in the marine environment. Some indication of re-suspension and redistribution of sediment after several weeks, suggesting risk to indigenous sediment dwelling crustaceans, such as crab or lobster. However, the mussels eliminated teflubenzuron readily. It is relatively non-toxic to marine species of birds, mammals and fish, due to its mode of action, but it is potentially highly toxic to any species which undergo molting within their life cycle** (Haya et al., 2005). Variation in sensitivity between individuals made it difficult to determine a break point (Samuelsen et al., 2014).
Anaesthetics	
Tricaine methane sulphonate (MS-222)	Worldwide use. **Typical dosage in aquaculture is 15-300 mg/L. No adverse environmental effects are foreseen with its use** (Fisheries and Oceans Canada, 2003). It is assumed to be biodegradable, but it is **recommended not to discard it into the environment** (OSPAR, 2009). Several authors illustrated that it could significantly alter fish blood plasma chemistry, but this has not been adequately investigated in marine species (Popovic et al., 2012). It elicited an aversive response in zebrafish at 50% of the effective dose, supporting the anecdotal evidence of its aversive nature put forward for salmonids and other species (Readman et al., 2013).
Disinfectants	
Hydrogen peroxide	Not in common use. **Typical dosage in aquaculture is 500 mg/L for up to 20 minutes**. There is **little information of the toxicity to marine organisms**. There is evidence that the concentrations used in sea lice treatments can cause gill damage and reduced growth rates for 2 weeks post treatment (Haya et al., 2005). **Although is toxic to some aquatic organisms,**

	including marine phytoplankton and crustacean, the rates of dilution and dissociation encountered on fish farms ensure that harmful effects on the environment are minimised (Marine Institute for SWRBD, 2007; Burridge et al., 2014).

Antibiotics: EU & Turkey

There is a growing awareness that over-use of antibiotics, for both human and animal health care, presents a serious concern as it could result in antibiotic resistance (antimicrobial resistance/AMR) and the proliferation of drug resistant diseases (PerformFISH 2019, Okocha et al. 2018, Caruso 2016, González-Renteria et al. 2016, Aly & Albutti 2014, EU 2014a, Douet et al. 2009, Çagirgan 2009). The European Parliament addressed the issue of maximum residue limits (MRLs) of VMPs permissible in foodstuffs of animal origin in 2009; based on their recommendation, the EU Commission formulated a proposal, which in turn was accepted by all EU member states, and subsequently led to the introduction of Regulation (EC) No. 470/2009[59]. Awareness of this issue in the EU is now such that most member states have developed national action plans and strategies to tackle MRL and AMR. These publications are available on the website of the European Centre for Disease Prevention and Control (ECDPC)[60]. Additionally, the European Commission adopted the '*One Health Action Plan against Antimicrobial Resistance*'[61] in 2017, the overarching goal of which is to "*Preserve the possibility of effective treatment of infections in humans and animals*". The WHO Regional Office for Europe, whose member states include EU countries plus Turkey[62], is also actively engaged in tackling AMR across the region. Turkey is also a member of WHO's Central Asian and Eastern European Surveillance on Antimicrobial Resistance (CAESAR)[63] network, a similar initiative which collects data on antibiotic use and aims to prevent the emergence and spread of AMR. Since implementing their AMR surveillance system in 2011, Turkey has reportedly noted a decline in general antibiotic use in recent years[64]. CAESAR's data, taken together with data from the European Antimicrobial Resistance Surveillance Network (EARS-Net), facilitates an overview of AMR surveillance records across the region.

A recent report on '*Best therapeutics practices for Mediterranean farmed fish*', published as part of the EU-funded PerformFISH project, notes that there is minimal information available on minimum inhibitory concentrations (MIC) pertaining to the antibiotics used to treat the various bacterium that affect farmed seabass and seabream and that establishing standardized data in this regard would help further reduce antibiotic use (PerformFISH 2019). Asides from human and target organism concerns with over-use of antibiotics in aquaculture, antibiotic use may also impact non-target organisms (Rico et al 2018). In instances where antibiotics are used on fish farms in Europe, they are generally administered in feed (PerformFISH 2019), which

---

[59] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R0470&from=EN
[60] https://ecdc.europa.eu/en/publications-data/directory-guidance-prevention-and-control/antimicrobial-resistance-strategies
[61] https://ec.europa.eu/health/amr/action_eu_en
[62] http://www.euro.who.int/__data/assets/pdf_file/0005/136454/e94889.pdf
[63] http://www.euro.who.int/en/health-topics/disease-prevention/antimicrobial-resistance/surveillance/central-asian-and-european-surveillance-of-antimicrobial-resistance-caesar
[64] http://www.euro.who.int/en/health-topics/disease-prevention/antimicrobial-resistance/news/news/2017/11/turkey-takes-strong-action-to-reduce-antibiotic-consumption-and-resistance

arguably reduces the amount of therapeutants dispersed into the environment in comparison to bath treatments (OSPAR 2009). However, the bioavailability of antibiotics is much reduced in seawater compared to freshwater and the leaching of antibiotics from medicated feeds, which are also less palatable than regular feeds (PerformFISH 2019), is of greater concern when administered in marine environments (Daniel 2009). An EU brief on the development of sustainable aquaculture notes that the effect of discharged antibiotics from aquaculture facilities is poorly understood, and references one study of a Greek seabass farm, which estimated that 60-73% of the oxytetracycline included in medicated feeds was expelled in feces (SEP 2015). Other authors have also studied the pharmacokinetics of antibiotics administered in fish feed (PerformFISH 2019) to estimate the percentage that is excreted after being ingested: Lulijwa et al. (2019) suggest that 30-90% is expelled in this manner, whereas the approximation offered by Cabello et al. (2013) is 80%. In this regard, a recent study in Greece, which was part of the ongoing TAPAS (Tools for Assessment and Planning of Aquaculture Sustainability)[65] project, included an analysis of sediments and biota collected from 48 seabream and seabass farms, in order to measure the quantities of antibiotics that were present. The authors concluded, "*This study shows that the contamination with antibiotics in sediments underneath Greek cages is very sparse (only 7% of the farms showed antibiotic residues), and concentration levels are relatively low (in the order of* [a] *few µg/kg dw). Flumequine was the only compound detected. Besides antibiotic application practices (which were not assessed in this study), this result could be related to the high persistence of this compound in marine sediments,*" (Van den Brink et al. 2019, Kalantzi et al. 2019).

It is relevant to note that when antibiotics are administered in European aquaculture, this most often occurs during the early stages of development, particularly while fish are still within the confines of the hatchery, which falls outside of the scope of this assessment (Van den Brink et al. 2019). The aforementioned EU brief on the development of sustainable aquaculture also notes that improvements in husbandry practices combined with stricter regulations mean that antibiotics are generally only "*used as a last resort*" in European aquaculture, though no usage rates or patterns are described in this document (SEP 2015). The advice of EU veterinary experts also echo this, noting that the few antibiotics currently approved for use in medicated aquaculture feeds are strictly regulated and have been subject to stringent EIA procedures (pers. comm. Bill Vandaele, Dr Vet Med-Lic Zoot-E.P.A-MAVC, November 2019, PerformFISH 2019). As noted in the VICH (International Cooperation on Harmonisation of Technical Requirements for Registration of Veterinary Medicinal Products) guidelines, which are adhered to during the process of EIA in all VICH regions (currently EU, US and Japan), EIAs conducted for the purpose of obtaining an aquaculture VMP market authorization require the compilation of a detailed dossier, incorporating a physical/chemical analysis of each proposed VPM, as well as environmental fate and environmental effects studies to determine if there is an indication of risk attributable to these substances[66]. Experts and veterinary professionals within the sector also note that antibiotic use in European aquaculture has diminished drastically in recent years, commensurate with increased availability and use of effective vaccines, though no

[65] https://tapasproject.org
[66] https://www.vichsec.org/en/about/what-is-vich.html

quantification of this reduction is available (pers. comm. Bill Vandaele, Dr Vet Med-Lic Zoot-E.P.A-MAVC, November 2019; John A. Theodorou, PhD., December 2019; Nafsika Papageorgiou, PhD., November 2019; Van den Brink et al. 2019, Rico et al. 2018), as is also attested to by experts in the Turkish sector, who note that vaccination of fish at 20-40 g has had a positive impact in reducing antibiotic use on seabass and seabream farms in the region (Ferit Rad, PhD., November 2019).

According to the European Commission's recent '*Overview Report on Measures to Tackle Antimicrobial Resistance (AMR) Through the Prudent use of Antimicrobials in Animals*', which submitted questionnaires to the relevant Competent Authorities in each EU member state, all antibiotics used for aquaculture must be obtained via a prescription, generally from a veterinarian but occasionally through a fisheries biologist (EU 2018c). It should be noted here that the new Regulation 2019/6, discussed in more detail below, will prohibit this use via fisheries biologists and prescriptions will only be issued by a veterinarian (pers. comm. Bill Vandaele, Dr Vet Med-Lic Zoot-E.P.A-MAVC, November 2019). In practice, however, oxytetracycline, sulphadiazine/trimethoprim, and florfenicol are typically the only antibiotics used in production of the species under consideration; this is because commercial products based on other approved antibiotics are either not available or not easy to obtain (pers. comm. Philippe Sourd, DVM PhD, November 2019). Of note, Rico et al. (2018) state that oxytetracycline and florfenicol are the primary antibiotics used in aquaculture in the whole European Economic Area (EEA), which includes Norway and Iceland. In Turkey, the antibiotics most widely used are oxytetracycline, florfenicol and enrofloxacin (pers. comm. Ibrahim Cengizler, Prof., May 2018; Çagirgan 2009), and to a lesser extent, sulphadiazine/trimethoprim, amoxicillin and erythromycin (pers. comm. Ahmet Mefut, DVM, September 2019).

As noted above, oxytetracycline is considered highly important for human medicine by the WHO, while oxolinic acid, flumequine and amoxicillin are all considered critically important for human medicine (WHO 2019), and enrofloxacin and erythromycin, which are approved for use in marine aquaculture in Turkey but not in the EU, are also both listed as being critically important antibiotics for human medicine (WHO 2019). Although minimal research has been conducted into the potential aquatic environmental impacts of enrofloxacin (Tornero & Hanke 2016), fluoroquinolones, the antibiotic group to which enrofloxacin belongs, are known to sorb strongly to sediment and sludge, which may limit or destroy its antimicrobial activity (Borecka et al. 2015). Substances which are banned for use in food-producing animals in Turkey are: chloramphenicol, furazolidone nitrofurans, chlorpromazine, chloroform, colchicine, dapsone, dimethridazole, metridazole and ronidazole (pers. comm. Ahmet Mefut, DVM, September 2019).

Since 2010, European sales of veterinary antimicrobials have been recorded and monitored by the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) (ESVAC 2019, Okocha et al. 2018). As can be noted in Table 7, according to the EMA's most recent ESVAC report, it is mandatory for all EU seabass, seabream and meagre producing countries to report their antibiotic usage to their relevant country authorities (with the exception of Spain, although Spain evidently still provide data on antibiotic usage to EMA). ESVAC reports also provide the specific country-by-country quantities of each type of antibiotic that are used, as well as the aggregated quantities of these that are used by each country for each group of food-producing animals that are farmed. In ESVAC reports, sales of antibiotics are calculated with reference to the weight of active ingredient per unit of livestock biomass, or PCU (Population Correction Unit).

Table 7: Data extracted from the European Medicines Agency's ninth ESVAC report on '*Sales of veterinary antimicrobial agents in 31 European countries in 2017*' - showing trends from 2010 to 2017 (ESVAC 2019)

Country	Years collecting data	Legal basis	National data provider to ESVAC	Estimated PCU* of Fish** treated (i.e. total biomass in MT 1,000s)	Sales data, prescription data or purchase data***
Croatia	4 years	Mandatory to report	Ministry of Agriculture, Veterinary Directorate	17	Sales to pharmacies and veterinarians
Cyprus	> 5 years	Mandatory to report	Ministry of Agriculture, Natural Resources and Environment - Veterinary Services	zero or insignificant amount reported	Sales to veterinarians, pharmacies and farmers
France (includes usage in Atlantic Ocean)	> 5 years	Mandatory to report	National Agency for Veterinary Medicinal Products (AnsesANMV)	45	Sales to veterinarians, pharmacies, wholesalers and feed mills
Greece	3 years	Mandatory to report	Greek National Organisation for Medicines	126	Sales to pharmacies and veterinarians
Italy (includes usage in Atlantic Ocean)	> 5 years	Mandatory to report	Italian Ministry of Health	59	Sales to wholesalers, pharmacies, feed mills, and farms authorised to produce medicated feed for self-consumption
Portugal (Atlantic Ocean)	> 5 years	Mandatory to report	General Directorate for Food and Veterinary Affairs	11	Sales to retailers, veterinarians, farmers, producer organisations, veterinary clinics and feed mills
Spain (includes usage in Atlantic Ocean)	> 5 years	Not mandatory to report	Spanish Agency for Medicines and Health Products	351	Sales to veterinarians and veterinary organisations

*** The population correction unit (PCU) has been established as a denominator for the sales data included in ESVAC calculations, i.e. the estimated weight at treatment of livestock and of slaughter animals.**

**** Note that these data are for the calculated biomass of all fish treated in the country in question, not only seabass, seabream and meagre.**

****** Purchase/import data from, e.g., pharmaceutical industry and/or from wholesalers in other countries.**

The ESVAC program does not presently identify drug usage that is specific to the seabass, seabream and meagre sector, as only one generalized group of 'fish' is identified in the reporting format, which encompasses the entire aquaculture sector. As is noted in the following section, legislation to facilitate mandatory farm-level collection of such data will be initiated in 2022, thus species-specific data in this regard should be available in the near future. Of note, farmers in some jurisdictions are establishing a voluntary data reporting system regarding their usage of chemotherapeutants and antibiotic treatments (pers. comm. John A. Theodorou, PhD., December 2019), which should help facilitate a smooth transition to this new regulatory regimen. Publicly available data concerning the quantities of antibiotics specifically used by the aquaculture sector do not appear to be available in Turkey at the present time either (pers. comm. Ahmet Mefut, DVM, September 2019).

Although quantitative data in this regard is not readily available in the public realm, industry veterinary experts advise that, on average, antibiotics are administered significantly less than once per production cycle by farmers in the EU (pers. comm. Philippe Sourd, DVM PhD, November 2019). However, information gathered from the Hellenic Aquaculture Producers Organization (HAPO), representing >90% of the Greek aquaculture industry and over half of all seabass, seabream, and meagre production in the EU, indicated that 17% of seabass, 11% of seabream, and 0% of meagre production received an average of >3 antibiotic treatments per growout cycle from 2016-2018 (pers. comm. John A. Theodorou, PhD., December 2019); by first principles, this means that 83% of seabass, 89% of seabream, and 100% of meagre production received an average of 0-3 antibiotic treatments per production cycle over the same time period. Critically important antimicrobials for human medicine were used in 6% of total treatments in 2019, a decline from 31% in 2017 and 13% in 2018. Unfortunately, no further quantification of antibiotic treatments could be obtained, particularly with respect to the percentage of production that has never been treated. Despite the statements of veterinary experts suggesting that antibiotics are applied significantly less than once per production cycle in the EU, available data could not confirm this and given the lack of clarity with regard to treatment frequency, type, and volume, it is considered that highly and critically important antimicrobials are being used in unknown quantities.

It is pertinent to note that scientific literature has, for some time, been reporting on the increased use of vaccines by the sector (Subasinghe 2009). Numerous experts comment that there has been a dramatic decline in antibiotic use in European aquaculture in recent years and that the primary reason for this is the development and implementation of effective vaccines (pers. comm. Bill Vandaele, Dr Vet Med-Lic Zoot-E.P.A-MAVC, November 2019, Nafsika Papageorgiou, PhD., November 2019, Ferit Rad, PhD., November 2019). Additionally, 100% of fish stocks are routinely vaccinated by virtually all producers in the EU and Turkey, where area management agreements between producers typically stipulate 100% vaccination of stocks as a requirement (pers. comm. Philippe Sourd, DVM PhD, November 2019). An expert from the

Greek sector also commented that, as a consequence of routine vaccination against Vibriosis and Pasteurellosis, neither of these diseases present a significant threat to the seabass industry anymore and that the last significant outbreak of Vibriosis in the country occurred in 2000 (pers. comm. John A. Theodorou, PhD., December 2019). Although vaccines are not assessed in this Chemical Use Criterion, since Seafood Watch does not consider their use to have an ecological impact, their increased uptake has arguably had an indirect, yet commensurately positive ecological effect by reducing the industry's reliance on antibiotics. The application of vaccines will be discussed further in Criterion 7 – Disease.

A number of antibiotic resistance assays have been conducted on farmed fish in the Mediterranean region. These have detected some evidence of bacterial resistance to a range of antibiotics, particularly with regard to the aetiological agents of vibriosis and pasteurellosis, diseases that have a significant impact on Mediterranean aquaculture. One study of farmed gilthead seabream in Italy detected antibiotic resistance of Vibrio spp. to both licensed and unlicensed antibiotics (Scarano et al. 2014), and a similar study on *Vibrio alginolyticus*, which was isolated from diseased farmed seabass in Turkey, also detected instances of resistance when a range of antibiotics were tested (Korun et al. 2013). Another study in Italy, which assayed the resistance of bacterial pathogens, Vibrio and *P. damselae* subsp. *Piscicida* that had been isolated from fish, including seabass and seabream, plus shellfish and crustaceans, also detected varying degrees of sensitivity to a range of antibiotics (Laganà et al. 2011). It is important to acknowledge, however, that many anthropogenic activities have evidently contributed to this development of antibiotic resistance in the Mediterranean marine environment, not only aquaculture (PerformFISH 2019).

Antifoulants: EU & Turkey

The aforementioned EU brief on the development of sustainable aquaculture (SEP 2015) also highlights the potential ecological ramifications of antifoulant use. Copper, which is the most commonly used active component in antifoulant formulations, is known to negatively impact non-target organisms (Tornero & Hanke 2016). Tributyltin, a commonly used antifoulant in the past, has not been permitted for use in aquaculture for around thirty years and was specifically banned in the EU by Directive 2002/62/EC (OSPAR 2009). Other antifouling compounds used in aquaculture include chorothalonil, copper pyrithione (CuPT), dichlofuanid, sea-nine 211, diuron, irgarol-1051, TCMS pyridine, zinc pyrithione (ZnPT), and zineb (Guardiola et al. 2012). To enhance efficacy, biocides[67] are often included in antifouling formulations. Guardiola et al. (2012) note that: "*Several studies have evaluated the toxicity of booster biocides on non-target species and have found most of them to be growth inhibitors for freshwater and marine autotrophs, influencing key species, such as sea grasses and corals. Therefore, there is increasing interest in the impact of these compounds on the aquatic ecosystems*," and "*With the rapid expansion of the aquaculture industry and with the tightening of the legislation on the use*

[67] The official website of the European Union defines a biocide thus: "*According to the Biocides Directive (98/8/EC), biocidal products are those that are intended to destroy, render harmless, prevent the action of, or otherwise exert a controlling effect on any harmful organism by chemical or biological means. Examples include disinfectants, preservatives, antiseptics, pesticides, herbicides, fungicides and insecticides*".

of antifouling biocides, the problems of aquaculture biofouling have increased." It should be noted that the only biocides currently authorized for use in EU aquaculture are those which have received approval pursuant to an EIA (pers. comm. Bill Vandaele, Dr Vet Med-Lic Zoot-E.P.A-MAVC, November 2019) in accordance with EU Regulation 528/2012[68]. In addition to this, the risks of all chemicals in the EU are assessed by the REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulation, which "*places the burden of proof on companies*" to convey how their products can be used safely, including the communication of any risk mitigating measures that must be taken to achieve this[69]. Similar provisions are in place in Turkey in Law No. 5996 on Veterinary Services, Plant Health, Food and Feed[70].

Parasiticides: EU & Turkey

Turkish Law No. 5996 is also applicable to parasiticide use in the aquaculture sector. In the EU, parasiticides are regulated as a VMP, therefore an EIA is required before they can be authorized (pers. comm. Bill Vandaele, Dr Vet Med-Lic Zoot-E.P.A-MAVC, November 2019). However, limited discussion of parasiticide use by the sector under consideration was noted in literature, even though it is evident that seabream suffer significantly from seasonally fluctuating occurrences of *Sparicotyle chrysophrii*, an ectoparasite that attaches itself to the gill epithelium. Presently, there is evidently no effective remedy available for the treatment of fish parasitized by *S. chrysophrii,* asides from the use of formalin baths, which the most recent PerformFISH report (2019) indicates is commonly used. The need to develop effective treatments for this condition is one of the priorities being addressed currently by the ongoing EU-funded ParaFishControl (Piazzon e al. 2019, PerformFISH 2019) project, and is discussed further in the Disease Criterion. Although a limited number of chemical substances, such as diflubenzuron, have been used experimentally over the last few decades to treat parasite infestations in farmed seabass and seabream, formalin baths are the only legally permissible antiparasitic agent available to fish farmers in many jurisdictions, including Greece and Spain, thus this control strategy has been the one most widely employed by industry in the treatment of ectoparasites for many years. Reportedly, however, there is a high possibility that this compound will be banned for use in food-fish in future. Minor use of in-feed antiparasitics, such as emamectin benzoate, has been noted as a treatment for copepodic parasites, such as *Lernanthropus kroyeri*, in Greek seabass production (pers. comm. John A. Theodorou, PhD., December 2019). Hydrogen peroxide, which is commonly used as a disinfectant in aquaculture, is also used to combat ectoparasites (PerformFISH 2019). Asides from formalin, the Turkish sector also use the disinfectant chloramine-T (pers. comm. Ibrahim Cengizler, Prof., May 2018, Çagirgan 2009). No quantification of parasiticide application frequency could be made.

Legal provisions for the maintenance of good chemical and ecological status in European waters

As discussed in Criterion 2, the overarching purpose of the EU's WFD (Directive 2000/60/EC) is to keep inland and coastal waters clean by controlling the input of nutrients and chemicals. This objective has been further supported over the years by an array of legislative acts (PerformFISH

[68] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:167:0001:0123:EN:PDF
[69] https://echa.europa.eu/regulations/reach/understanding-reach
[70] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC106155/

2019, EC 2016) and most recently by adoption of '*Regulation (EU) 2019/6 of the European Parliament and of the Council of 11 December 2018 on veterinary medicinal products and repealing Directive 2001/82/EC*' (EU 2018b). As alluded to in its full title, Regulation (EU) 2019/6 repeals and replaces Directive 2001/82/EC, which was previously the main legislative instrument governing the aquaculture sector's use of chemicals and veterinary medicinal products. The introduction of Regulation (EU) 2019/6 EU was deemed necessary in order to keep abreast of current scientific progress but it is also important to note that, by definition, this updated EU act infers a tightening of legislation in this regard due to the change of nomenclature of this governance tool from 'directive' – a goal that leaves flexibility to the member state in order to meet it – to 'regulation' – a binding legislative act applied across the EU.

The Regulation also requires the collaborative development of a 'Union pharmacovigilance database'[71] which will facilitate transparency and the efficient dissemination of information between member states concerning the efficacy and safety of VMPs used by the sector. The development and implementation of this database aims to ensure that good practices, with regard to VMP usage, are adhered to by all parties and facilitated by the sharing of evolving knowledge (EU 2018b). The Regulation stipulates that an EIA is mandatory for all new veterinary medicines prior to seeking marketing authorization approval, and this process must particularly address the following:

- The target animal species and the proposed pattern of use,
- The method of administration, in particular the likely extent to which the product will enter directly into the environmental system,
- The possible excretion of the product, its active substances into the environment by treated animals, persistence in such excreta,
- The disposal of unused or waste product[72]

This risk/benefit approval process is to ensure that any environmental impacts brought about by the use of veterinary medicines will be minimal when these products are used in accordance with their label; EIA requirements, including the provision of ecotoxicity data, were first instigated with the passing of Directive 92/18/EC in 1992, and has been a standard part of market authorization (MA) submissions since this time. Guidance documents concerning EIAs have evolved over the last few decades (CVMP 2016) and the new Regulation seeks to further harmonize and simplify the process.

At present, there are three potential avenues through which a VMP can become authorized for use in the EU: either via a centralized route (single market authorization), a decentralized route, or a national route (pers. comm. Bill Vandaele, Dr Vet Med-Lic Zoot-E.P.A-MAVC, November

[71] https://www.ema.europa.eu/en/human-regulatory/overview/pharmacovigilance-overview
[72] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0006&from=EN

2019); regardless of the route taken, an EIA is mandatory for all new applications[73]. Centralized approval for medicines is conducted by the European Medicines Agency (EMA)[74], which was initially established in 1993 by Regulation (EEC) No. 2309/93[75]; VMPs approved in this way are automatically licensed for use throughout the EU in all member states and the majority of new and innovative medicines are approved via this route. However, most medicines in use in the EU have sought market authorization via the decentralized procedure or at the national level, either because they were introduced prior to the establishment of the EMA in 1993 or because their use lies outside the mandatory scope of the EMA; in such cases, the VMP is not automatically authorized in all member states. At present, there is only one EMA centrally authorized aquaculture medicine (aimed at Atlantic salmon); all other aquaculture VMPs currently in use are approved at the regional level by the veterinary Competent Authority of each member state[76].

In addition to compulsory EIAs, Regulation (EU) 2019/6 also includes provisions for the Competent Authority of member states to be audited to ensure the effectiveness of their VMP controls. The Regulation also introduces the concept of limiting the accessibility of antibiotics that are of high and critical importance to humans, in consideration of recommendations from international organizations, such as WHO, the World Organisation for Animal Health (OIE), and the Codex Alimentarius (EU 2018b). Of note, Article 57 of the new veterinary Regulation 2019/6 requests member states to collect data on the sales and use of antimicrobials, including those used for food-producing animals at the farm level, and this requirement will become applicable in January 2022, with a five-year phase-in period before it becomes mandatory. Some European nations, notably Norway, already collect farm-level data, and others, such as France, have a dedicated web platform on which they report national antibiotic usage[77]. In comparing the ESVAC reports from previous years[78] to the most recent one for and 2017 (ESVAC 2019), it is evident that changes in antibiotic reporting are occurring at the national level in countries where seabass, seabream and meagre are farmed: although both France and Italy reported their 2014 usage levels to EMA, this did not become a mandatory national requirement in these two countries until 2015; Greece, by comparison, did not collect antibiotic usage data at all in 2014[79], however it became a mandatory requirement in 2015. Turkish laws governing the use of VMP in aquaculture, specifically Law No. 5996 on Veterinary Services, Plant Health, Food and Feed[80] plus Aquaculture Regulation No. 25507[81],

---

[73] https://ec.europa.eu/health/sites/health/files/files/eudralex/vol-6/ne_en_doc/2009-03-17_era-cvmp_nta_en.pdf
[74] https://www.ema.europa.eu/en/about-us/what-we-do/authorisation-medicines
[75] regulation (eec) no 2309/93/ec
[76] https://www.ema.europa.eu/en/partners-networks/eu-partners/eu-member-states/national-competent-authorities-veterinary
[77] https://www.anses.fr/en/content/monitoring-sales-veterinary-antimicrobials
[78] https://www.ema.europa.eu/en/veterinary-regulatory/overview/antimicrobial-resistance/european-surveillance-veterinary-antimicrobial-consumption-esvac
[79] http://www.saveourantibiotics.org/media/1755/farm-antibiotic-use-in-greece.pdf
[80] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC106155/
[81] https://www.ecolex.org/details/legislation/aquaculture-regulation-no-25507-lex-faoc044968/?q=Aquaculture+Regulation+No.+25507

are also aligned with EU Directives and Regulations (Cengizler et al. 2017, Çagirgan 2009, Yücel-Gier et al. 2009), and lay out the procedures necessary for VMP's to be approved and produced. It is unclear if similar measures to those described above, i.e. the collection of farm-level data concerning antimicrobial use, will be adopted in Turkey also, however, Turkish law stipulates that all VMPs for aquaculture must be prescribed by a veterinarian (FAO 2005-2018a) and Law No. 5996 stipulates that veterinarians must submit all prescription records to MARA (Ministry of Agriculture and Rural Affairs) when requested to do so.

Chemical Use & Governance: Egypt

Information pertaining to chemical use by the Egyptian seabass, seabream and meagre sector is somewhat lacking. No information concerning governance of chemical and drug use for the sector was identified in literature. Concerning tilapia production, which accounts for 67% of domestic aquaculture production (FAO 2019), Eltholth et al. (2014) comment that: "*About 30% of producers use treatments; 66.7% use antibiotics, 16.7% use growth promoters, 13.3% use probiotics, and 3.3% use potassium permanganate. Of those who use medication, 73.3% buy them from private veterinarians, 20% from pharmacies, and 6.7% from local shops*," indicating that numerous chemicals are evidently in use by the Egyptian aquaculture sector at large.

It is also evident from general literature on Egyptian aquaculture that concerns exist with regard to chemical contamination of farmed fish arising not from aquaculture practices but from agricultural run-off laden with heavy metals and pesticides (Eltholth et al. 2018, Shaalan et al. 2017, Eissa et al. 2016, Eltholth et al. 2015, Heijden et al. 2014, CGIAR 2012). Interestingly, Eltholth et al. (2015) comment that: "*The main constraints to tilapia exports in Egypt are the absence of both a residue monitoring system and a disease testing framework required by EU and US authorities"*; broadly, Egypt does not export these products to the EU and US, and thus no information from any import data could be used to infer chemical usage in the sector.

Although no data was found which demonstrates that controls are in place to govern the sector's use of chemicals, a number of studies were identified which discuss the efficacy of a range of antibiotics on pathogens impacting cultured seabream, seabass and meagre in the region. These data show that many pathogens affecting these cultured species are becoming resistant to a range of antibiotics, including those which are ranked by WHO as being highly important or critically important for human medicine (WHO 2019). One such study produced an antibiogram profile of the pathogenic Vibrio/Photobacterium species which were identified during a disease outbreak that caused mass mortalities in cultured Egyptian seabream and seabass in 2013 (Abdel-Aziz et al., 2013). During the study, these pathogenic microorganisms were exposed to an array of antibiotics to test their sensitivity. It was discovered that, while the isolated pathogens were sensitive to ciprofloxacin, chloramphenicol, enrofloxacin, nalidixic acid and oxolinic acid, they were resistant to ampicillin, amoxicillin, and lincomycin. While the disease outbreak was likely caused by numerous factors (e.g. seasonal effects, poor water quality, etc.), the authors posit that the evident resistance was a consequence of repetitive antibiotic usage in controlling previous outbreaks, as well as the consistent presence of antibiotics in coastal waters due to agricultural and municipal runoff. While this study does not provide conclusive evidence that irresponsible drug use by the seabream, seabass and meagre sector in Egypt is contributing toward antimicrobial resistance (AMR), it does indicate that national controls are lacking with regard to VMP use.

A similar study on Egyptian cultured seabream stated that haphazard use of broad-spectrum antibiotics within the sector was causing resistant strains of *Pseudomonas aeruginosa* to emerge (Khalifa et al. 2016). Numerous other authors have also noted the emergence of resistant strains of pathogens affecting national production of seabream, seabass and meagre, documenting the inefficacy of critically and highly important antibiotics upon these isolates (Fadel et al. 2018, Essam et al. 2016, El-Barbary 2010). These data are generally inconclusive about the source of AMR but strongly suggest that the aquaculture sector is contributing to this impact. Of note Essam et al (2016) identify that ampicillin, rifampicin, gentamicin, nitrofurantoin, ciprofloxacin, cefotaxime, oxytetracycline, trimethoprim/sulfamethoxazole, florfenicol, and vibriostatic agent O/129 are drugs which are used commercially in the treatment of disease in the region.

Of note, a new government agency, the National Food Safety Authority (NFSA)[82], was recently established with the enactment of Law No. 1 of 2017[83]. This new authority is tasked with the development of mandatory food safety and traceability systems, which are aligned with international standards. This act, in which farm-raised fish is specifically referenced, should effect greater control measures with regard to the potential accumulation of antibiotic residues in aquaculture products, as well as the quality of the water source available for fish farms in the Nile delta, which is primarily agriculture drainage water (pers. comm. Dr. Shérif Sadek, December 2019).

Conclusions and final score

Due to the regional differences highlighted in this production parameter review on chemical use, three separate scores have been assessed: one for the EU, one for Turkey, and one for Egypt.

In general, the regulatory framework that is in place to govern drug use by the aquaculture sector in the EU and Turkey would appear to be somewhat effective in limiting the use of antibiotics due to the requirement for veterinary prescriptions, though chemicals that are highly and critically important to human medicine are approved for use in both jurisdictions. Although some evidence of resistance to antibiotic treatments have been documented in studies of Mediterranean farmed seabass and seabream, these studies do not attribute this situation to misuse of antibiotics by the aquaculture sector, per se, but note that there are an array of contributory anthropogenic factors. In recent years it has become mandatory in most EU member states to report the quantities and types of antibiotics used in food-animal

---

82 http://www.nfsa.gov.eg/(S(ztygrkxgxqqvnqjkypjygj2v))/App_PP/DeskTop/App_Web/App_Custom/1/Default.aspx?TabID=10000000

83 http://www.nfsa.gov.eg/Images/App_PP/DeskTop/App_Web/1/MyWebMedia/PDF/Law%20on%20the%20National%20Food%20Safety%20Authority-English%20V%202%20May%202019.pdf

production to the centralized European Medicines Agency and, in Turkey, veterinarians must make their prescription records available for inspection when requested. New EU legislation has also mandated that farm-level details of antibiotic use must be reported, with a phase-in period commencing in 2022 – although data concerning sector-specific usage is not publicly available at the present time in either the EU or Turkey. Communications with veterinary professionals within the sector, both in the EU and Turkey, suggest that antibiotic use in the sector has reduced significantly in recent years, commensurate with the increased availability and routine application of effective vaccines by seabass, seabream and meager farmers, with close to 100% of stocks reportedly being vaccinated against several bacterial diseases. Antibiotic use data for fish are available in the EU, but not disaggregated at the species level, thus specific usage data for the seabass, seabream and meagre sector are unknown. While communication with some industry veterinarians have indicated that antibiotics are typically used less than once per cycle, additional information suggests that antibiotic use is common in Greece (>50% of total EU production), with no quantification of treatment frequency beyond a minority of the industry exceeding 3 treatments per cycle. Further information indicates that critically-important antimicrobials for human medicine were used in 6% of all antibiotic treatments in Greece in 2019 (a decrease from 30% in 2017), though again, total volume and number of treatments are unknown. No such quantifications of antibiotic use in Turkey could be ascertained.

Overall, despite increased vaccinations and indications from veterinary professionals that antibiotics are typically used less than once per production cycle, additional data indicate that the use of antibiotics in Greece, the major EU producer country, is common and at times, frequent (>3 treatments per cycle). Given the available data and uncertainty in treatment frequency, it is considered that highly important antimicrobials are being used in unknown quantities in the EU, and critically important antimicrobials are being used in unknown quantities in Turkey. In addition, parasiticides such as formalin are in use in both sectors, with no indication of the treatment volumes or frequency able to be ascertained. Net pens are an inherently open production system that allow the discharge of active chemicals, and therefore, an intermediate score is warranted for each sector. The difference in the scores between the EU and Turkey are driven by the unknown usage patterns of different antimicrobials, greater data availability in the EU, as well as more stringent regulatory control in the EU.

The final score for Criterion 4 – Chemicals: EU is 3 out of 10, whereas the final score for Criterion 4 – Chemicals: Turkey is 1 out of 10.

Data on the Egyptian sector suggests that there is a lack of regulatory control concerning chemical use by producers of the species under consideration and this necessitates that a precautionary approach is used to score this Criterion. This method of evaluation is further supported by data which demonstrates the development of antibiotic resistant pathogens within the aquaculture sector at large; this includes the usage of chemicals which are critically important to human health, which appear to be being used in unknown quantities. The final score for Criterion 4 – Chemicals in Egypt is 0 out of 10.

Criterion 5: Feed

Impact, unit of sustainability and principle

- Impact: feed consumption, feed type, ingredients used, and the net nutritional gains or losses vary dramatically between farmed species and production systems. Producing feeds and their ingredients has complex global ecological impacts, and their efficiency of conversion can result in net food gains, or dramatic net losses of nutrients. Feed use is considered to be one of the defining factors of aquaculture sustainability.
- Sustainability unit: the amount and sustainability of wild fish caught for feeding to farmed fish, the global impacts of harvesting or cultivating feed ingredients, and the net nutritional gains or losses from the farming operation.
- Principle: sourcing sustainable feed ingredients and converting them efficiently with net edible nutrition gains.

Criterion 5 Summary: European Seabass

Feed parameters	Value	Score
F5.1a Fish In: Fish Out ratio (FIFO)	0.87	7.82
F5.1b Source fishery sustainability score	-6.00	
F5.1: Wild fish use score		6.77
F5.2a Protein IN (kg/100kg fish harvested)	77.80	
F5.2b Protein OUT (kg/100kg fish harvested)	37.02	
F5.2: Net Protein Gain or Loss (%)	-52.41	4
F5.3: Feed Footprint (hectares)	16.26	4
C5 Feed Final Score (0-10)		**5.38**
Critical?	NO	**YELLOW**

Criterion 5 Summary: Gilthead Seabream

Feed parameters	Value	Score
F5.1a Fish In: Fish Out ratio (FIFO)	1.24	6.90
F5.1b Source fishery sustainability score	-6.00	
F5.1: Wild fish use score		5.41
F5.2a Protein IN (kg/100kg fish harvested)	71.36	
F5.2b Protein OUT (kg/100kg fish harvested)	35.89	
F5.2: Net Protein Gain or Loss (%)	-49.71	5
F5.3: Feed Footprint (hectares)	14.66	5
C5 Feed Final Score (0-10)		**5.21**
Critical?	NO	**YELLOW**

Criterion 5 Summary: Meagre

Feed parameters	Value	Score
F5.1a Fish In: Fish Out ratio (FIFO)	1.47	6.33

F5.1b Source fishery sustainability score	-6.00	
F5.1: Wild fish use score		4.57
F5.2a Protein IN (kg/100kg fish harvested)	57.24	
F5.2b Protein OUT (kg/100kg fish harvested)	30.67	
F5.2: Net Protein Gain or Loss (%)	-46.42	5
F5.3: Feed Footprint (hectares)	18.53	3
C5 Feed Final Score (0-10)		**4.28**
Critical?	NO	**YELLOW**

Criterion 5 Summary: Meagre farmed in Egypt using whole fish

Feed parameters	**Value**	**Score**
F5.1a Fish In: Fish Out ratio (FIFO)	9.00	0.00
F5.1b Source fishery sustainability score	-10.00	
F5.1: Wild fish use score		0.00
F5.2a Protein IN (kg/100kg fish harvested)	162.00	
F5.2b Protein OUT (kg/100kg fish harvested)	20.10	
F5.2: Net Protein Gain or Loss (%)	-87.59	1
F5.3: Feed Footprint (hectares)	64.37	0
C5 Feed Final Score (0-10)		**0.00**
Critical?	YES	**RED**

Brief Summary

Data to inform this Criterion has been sourced directly from the main commercial aquafeed suppliers to fish farms in both Egypt and the Mediterranean region. The economic FCRs used to score this Criterion are 2.3 for seabass, 2.0 for seabream and 1.7 for meagre. In addition, it is evident that production of meagre in Egypt is commonly fed whole fish, rather than commercial diets, and in such instances an eFCR of 9 has been used. In light of this, two separate ratings have been calculated for the Egyptian meagre sector.

With the exception of meagre produced in Egypt using whole fish, the FFER for seabass, seabream and meagre is 0.87, 1.24 and 1.47, respectively. Since the source fisheries used in all diets are the same, all three species score -6 out of -10 for Factor 5.1b. When added together, these scores result in a final Factor 5.1 score of 6.77 out of 10 for seabass, 5.41 out of 10 for seabream, and 4.57 out of 10 for meagre. Since most fish produced across the scope of this assessment are consumed in domestic markets, where fish are most frequently served whole, this has been factored into the calculations for Factor 5.2, and the resultant net protein gain/loss values for seabass, seabream and meagre are -52.41%, -49.71%, -46.42%, respectively, indicating a net loss of protein. The subsequent final Factor 5.2 score for seabass is 4 out of 10, whereas seabream and meagre both obtain a score of 5 out of 10. The total global land and ocean area appropriated per MT of farmed fish for seabass, seabream and meagre is 16.32 hectares, 14.71 hectares and 18.58 hectares, respectively, resulting in scores of 4, 5, and 3 for Factor 5.3. When the scores for all three Factors are combined, the final Criterion 5 – Feed score for seabass is 5.38 out of 10, for seabream it is 5.21 out of 10, and for meagre it is 4.28 out of 10.

In consideration of farmed meagre produced in Egypt on a diet of whole fish, the FFER is calculated to be 9, due to an eFCR of 9. Since the whole fish used as feed come from unknown source fisheries, this warrants a score of -10 out of -10 for Factor 5.1b; when these scores are combined, the final Factor 5.1 wild fish use score is zero out of 10. The Factor 5.2 score, which assesses net protein gain or loss, is 1 out of 10, due to a -87.59% net loss of protein. In consideration of the diet used, the ocean area appropriated per each MT of farmed meagre produced is calculated to be 64.37 hectares, resulting in a Factor 5.3 score of zero out of 10. The final Criterion 5 – Feed score for meagre farmed in Egypt using whole fish is therefore zero out of 10, which is a Critical conservation concern to Seafood Watch.

Justification of Rating

Overview of feed use by the sector

Feed data for the following feed analysis comes from a number of sources. Specific details concerning feed components has been sourced directly through personal communications with the main feed suppliers to the EU, Turkey and Egypt. These data have been further supported by information obtained from scientific literature, plus personal communications with industry experts. It should be noted, however, that cultivation of these species in Egypt is not necessarily always conducted solely with commercial diets; the use of whole fish, colloquially referred to as 'trash fish' (small tilapia, palaemonidae shrimp, sardines, etc.) has been noted in particular with meagre production (pers. comm. Dr. Shérif Sadek, December 2019). To take this into consideration, two separate calculations for meagre farmed in Egypt are presented below.

A Note on the Variability of Feed Conversion Ratios (FCRs)

The scope of this report incorporates an array of different management systems and site characteristics, which means that the range of reported FCRs for seabream, seabass and meagre varies somewhat across the scope and between these different farming scenarios. It should also be noted that the Seafood Watch Feed Criterion bases its scoring upon the economic FCR (eFCR), a measure of the total feed applied relative to the total harvest; this is different than the biological FCR, which simply describes the physical relationship between the units of feed consumed that are required to grow one unit of fish. For example, Janssen et al. (2017) define the biological FCR of seabream to be 1.8 and the economic FCR (eFCR) to be 1.92 (i.e. the latter figure takes all feed applied and all losses into account whereas the former does not).

Recent years have seen the vegetable protein component of feed increase while marine inputs have decreased; in addition to this, a greater percentage of these marine inputs are sourced from by-products (trimmings from processing, etc.). According to a recent article in International Aquafeed magazine, Mediterranean companies use between 1.8 and 2.2kg of feed to produce one kg of seabream (of 400g harvest weight)(International Aquafeed 2016). While many farmers elect to use commercial diets, some, particularly in Greece and Turkey, opt to produce their own diets via toll milling (pers. comm. feed expert, anonymous, June 2018).

This inevitably results in a wide variation in FCRs achieved across the scope. Data from the Federation of European Aquaculture Producers (FEAP) places the FCR for seabass and seabream at 2.0 and 2.3, respectively (AE 2014). These figures are broadly aligned with input received from industry experts who requested to remain anonymous, i.e. the FCR for seabream is 1.8 (eFCR 2 – 2.3) and for seabass it is 1.8 – 2.1 (eFCR 2.3 – 2.8). The lower end of these industry figures are based on average harvest-size 300-400g fish, whereas the higher FCRs reflect fish harvested at a larger size; additionally, the higher economic FCR for seabass is indicative of the higher mortalities experienced with this species for the duration of the production cycle (pers. comm. industry expert, anonymous, July 2018).

Some research studies, however, report substantially lower FCRs. Mongile et al. (2014), for example, reported a range of biological FCRs for seabream, ranging from 1.37 to 1.53, dependent upon water temperature and lipid content of diet. Studies in NW Greece (Nathanailides & Anastasiou 2015, Nathanailides et al. 2013) have recorded even lower FCRs for all three species under consideration.

With regards to meagre, the general consensus in literature is that this species displays more favorable FCR potential than either seabream or seabass (Duncan et al. 2013). FAO data sources (FAO 2005-2018b, Monfort 2010) indicate an average FCR of 1.7 for meagre, whereas a more recent Turkish study (Bodur et al. 2014), conducted during summer months with pond-grown meagre, reported an FCR of 1.48.

Clearly, there is some variability in reported FCRs, however, for the purposes of this report, the eFCRs obtained from FEAP and industry experts (for 300-400g fish) have been used for both seabass (2.3) and seabream (2.0). For meagre, the reported FAO FCR of 1.7 has been used. With regards to meagre farmed in Egypt using whole fish as feed, an FCR of 9 has been utilized in calculations, as per the advice of an expert in the sector (pers. comm. Dr. Shérif Sadek, December 2019).

Factor 5.1 Wild Fish Use

This Factor measures the amount of wild fish used to produce farmed fish, combined with the sustainability of the fisheries from which they are sourced. Factor 5.1 combines the amount of wild fish used (Factor 5.1a) with the sustainability of the source fishery (Factor 5.1b) to give a score from 0-10 for 'wild fish use'.

Factor 5.1a – Feed Fish Efficiency Ratio (FFER)[84]

Dependency on wild fisheries is measured by considering the quantity of wild fish used in feed in comparison to the harvested volume of farmed fish produced.

As Table 8 shows, there is a range of fishmeal and oil inclusions in seabass, seabream, and meagre feeds applied in the EU, Turkey, and Egypt. As noted, these data were sourced directly

[84] Also commonly referred to as the FFDR – Forage Fish Dependency Ratio or FIFO – Fish In: Fish Out Ratio

through personal communications with the main feed suppliers to the EU, Turkey, and Egypt and further bolstered through literature and personal communications with industry experts.

While there are several different methods of calculating FFER, the calculation used by Seafood Watch is the 'academic' calculation, as used in such literature as Tacon and Metian (2008) and in the multi-stakeholder Salmon Aquaculture Dialogue.

Table 8: The parameters used and their calculated values to determine the use of wild fish in feeding farmed seabass, seabream, and meagre in the EU, Turkey, and Egypt

Parameter	Seabass	Seabream	Meagre	Meagre (whole fish)
Fishmeal inclusion level	16%	17%	29%	22.5%
Percentage of fishmeal from by-products	62%	59%	40%	0%
Fishmeal yield (from wild fish)	22.5%[85]	22.5%	22.5%	22.5%
Fish oil inclusion level	10%	10%	12%	5%
Percentage of fish oil from by-products	81%	69%	64%	0%
Fish oil yield	5.0%[86]	5.0%	5.0%	5.0%
Economic Feed Conversion Ratio (eFCR)	2.3	2.0	1.7	9.0
Calculated Values				
Feed Fish Efficiency Ratio (FFER) (fishmeal)	0.62	0.62	1.31	9.00
Feed Fish Efficiency Ratio (FFER) (fish oil)	0.87	1.24	1.47	9.00
Seafood Watch FFER Score (0-10)	**7.82**	**6.90**	**6.33**	**0.00**

The Seafood Watch Feed Criterion considers the FFER from both fishmeal and fish oil, and uses the higher of the two to determine the score.

As can be noted, the score for Factor 5.1a – Feed Fish Efficiency Ratio is somewhat different for each of the three species under consideration: for seabass it is 7.82 out of 10; for seabream it is 6.90 out of 10; and for meagre it is 6.33 out of 10.

With regards to meagre farmed in Egypt using whole fish as feed, and using an eFCR of 9, the calculated FFER score is zero out of 10.

Factor 5.1b – Sustainability of the Source of Wild Fish

In order to assess the sustainability of the sources of wild fish used in the diets of seabream, seabass and meagre, information concerning these inputs has been sought from the main feed suppliers to the geographic scope of this report. The sustainability and status of these source fisheries have in turn been referenced in the FishSource database[87], an online resource which is maintained by the Sustainable Fisheries Partnership; Table 9 shows the FishSource

[85] 22.5% is a fixed value from the Seafood Watch Aquaculture Standard based on global values of the yield of fishmeal from typical forage fisheries. Yield estimated by Tacon and Metian (2008).
[86] 5% is a fixed value from the Seafood Watch Aquaculture Standard based on global values of the yield of fish oil from typical forage fisheries. Yield estimated by Tacon and Metian (2008).
[87] https://www.fishsource.org

sustainability scores of the wild fish stocks that are reportedly used in commercial seabream, seabass and meagre diets.

Table 9: Management quality and stock health status scores for wild capture species used in commercial diet formulations for seabream, seabass and meagre (FishSource database – https://www.fishsource.org)

FishSource Scores							
Common Name	**Scientific Name**	**Country Of Origin**	**Management Quality (NYS = Not yet scored)**			**Stock Health**	
		N-North C-Central S-South E-East	**Management Strategy**	**Manager's Compliance**	**Fisher's Compliance**	**Current Health**	**Future Health**
Anchoveta	*Engraulis ringens*	S Peru/N Chile regions XV-I-II	≥ 6	≥ 8	≥ 8	≥ 6	≥ 6
Anchoveta	*Engraulis ringens*	N-C Peru, incl. S Ecuador	≥ 6	≥ 8	10	≥ 6	≥ 6
Anchoveta	*Engraulis ringens*	C-S Chile regions V-X	≥ 6	10	≥ 6	≥ 6	7.4
Anchoveta	*Engraulis ringens*	C-S Chile regions III-IV	≥ 6	10	10	8	8.9
Atlantic Mackerel	*Scomber scombrus*	Morocco	NYS	NYS	NYS	NYS	NYS
Atlantic Mackerel	*Scomber scombrus*	NE Atlantic	≥ 6	0	10	10	7
Atlantic Chub Mackerel	*Scomber colias*	Spain/Portugal	NYS	<6	NYS	≥ 6	≥ 6
Atlantic Menhaden	*Brevoortia tyrannus*	USA	≥ 6	≥ 6	10	7.2	9.4
Blue Whiting	*Micromesistius poutassou*	Denmark	9.4	10	6.3	10	6.4
Capelin	*Mallotus villosus*	Denmark	≥ 8	10	10	≥ 6	≥ 6
Chilean Jack Mackerel	*Trachurus murphyi*	SE Pacific	≥ 6	≥ 8	10	8.1	10
European Pilchard	*Sardina pilchardus*	Morocco/ Spain	≥ 6	≥ 6	≥ 6	≥ 6	≥ 6
European Pilchard	*Sardina pilchardus*	Morocco/ Mauritania	≥ 6	≥ 6	<6 to ≥ 6	≥ 8	≥ 6
European Sprat	*Sprattus sprattus*	Denmark	≥ 6	9.5	10	10	2.2

Herring	*Clupea harengus*	Denmark	8.4	10	10	10	9.3

Factor 5.1b uses an average, or annual weighted mass-balance estimate of the fishery sources used in a typical feed to decide the appropriate sustainability of the source of wild fish score. It should be noted that, while Table 9 shows the FishSource score for each species used in commercial diets, there are often more than one source fishery for each species and not all fisheries will share exactly the same scores for each management or stock aspect considered; this is why the 'Fisher's Compliance' score for European pilchard is presented as a range of values (<6 to ≥ 6). While the majority of FishSource scores for species used in commercial diets for seabream, seabass and meagre are ≥ 6, four of these species have one score which falls below this level, indicating that there are a number of concerns to be taken into consideration in assessing their sustainability as feed inputs. However, the Seafood Watch Standard also considers certification by the Marine Stewardship Council (MSC)[88] or The Marine Ingredients Organisation (IFFO)[89] in assessing source fishery sustainability. In light of the fact that all of the wild fish inputs used in diets supplied to the sector under consideration are either MSC or IFFO certified, the appropriate score for Factor 5.1b is -6 (out of a possible range from 0 to -10).

The score for Factor 5.1b – Sustainability of the Source of Wild Fish is -6 out of -10 for all three species. The final Factor 5.1 scores, which are arrived at by combining the Factor 5.1a and Factor 5.1b scores, are as follows: for seabass it is 6.77 out of 10; for seabream it is 5.41 out of 10; and for meagre it is 4.57 out of 10.

With regards to meagre farmed in Egypt using whole fish as feed, the score for Factor 5.1b – Sustainability of the Source of Wild Fish is -10 out of -10 for unknown source fishery, as only a limited description of several species groups used as feed was given. When this is combined with the calculated FFER score of zero out of 10, the overall Factor 5.1 wild fish use score is zero out of 10 and is a Critical conservation concern.

Factor 5.2 Net Protein Gain or Loss

As is evident in Factor 5.1a and Table 8, the commercial diets for the three species under consideration differ somewhat and have discrete FM and FO inclusion levels. This is also evident in the scoring of Factor 5.2 – Net Protein Gain or Loss – since each species' feed has a slightly different protein percentage in its composition.

Concerning the edible yield of harvested fish, it is interesting to note a comment from Aquaculture Europe (AE 2014), which compares the farmed seabass and seabream market to that of farmed Atlantic salmon: "*Whole fish represents only 5-10% of the salmon market vs. >90% for seabass and seabream. On the other hand, the yield for fillet is 63% for salmon vs. 45% for seabass/seabream*". This is of great relevance to yield calculations since the edible yield obtained from a whole cooked fish is much higher than that obtained from a processed fillet. In

[88] https://www.msc.org
[89] http://www.iffo.net

the domestic markets of the Mediterranean region, where 90% of cultured seabream and seabass are consumed (Seafish 2015), fish are traditionally served whole (UCN 2018); this is evidently the case for 600g to 1kg meagre also (The Fish Site 2009), although demand for portion-sized meagre is apparently growing (Kružić et al. 2016). It is worth noting that meagre in the wild can reach 50kg (Kružić et al. 2016, Sanchez-Jerez 2013), seabass can grow to around 12kg (EC 2018b) and seabream to 4kg (Studer 2018). With this in mind, the calculations for Factor 5.2 are based on whole fish, since the majority of these farmed species are sold whole, gutted.

Factor 5.2 has two scoring options, depending upon the clarity of available information concerning the non-marine protein components of feed formulations. If feed formulations are completely transparent, then the non-edible[90] portion of formulations can be factored into the equation; however, if this level of detail is unknown then the entire protein quantity is calculated as being edible[91]. For this report, such detailed information has been provided in confidence by feed suppliers to the region under assessment; however, due to the proprietary nature of feed formulations, these data have been aggregated into the average values shown in Table 10. In general, the major protein providing crop ingredients include soybean meal, rapeseed meal, corn gluten, and whole wheat, while limited inclusions of land animal ingredients – poultry meal, feather meal, and blood meal – also contribute to the dietary protein levels in some diets. The majority of crop ingredients are considered edible, whereas land animal ingredients are not – please see Table A2 in the appendix of the Seafood Watch Aquaculture Standard for reference[92].

Calculating Edible Feed Protein Input

As per data in Factor 5.1a, varying amounts of marine protein inputs in the diets used to culture each species are from by-products, which are not considered to be edible in the calculation of this Factor. Any non-edible, non-marine components are also accounted for in this calculation and an adjustment made, as appropriate. It should also be noted that the protein content of fishmeal rendered from whole fish and from marine by-products is automatically calculated in the Seafood Watch scoring platform as 66.5%.

Table 10: The parameters used and their calculated values to determine the protein gain or loss in the production of farmed seabass, seabream, and meagre

Parameter	Seabass	Seabream	Meagre	Meagre (whole fish)
Protein content of feed*	42%	44%	43%	18%

[90] Note "edible" in this context relates to feed ingredients that would be suitable (or equivalent to those suitable) for human consumption.

[91] In this scenario, all protein from non-marine ingredients is considered to be from edible crops, which are considered to be the least efficient source of protein in aquaculture feeds (compared to the biological value of land animal proteins and marine proteins).

[92] https://www.seafoodwatch.org/-/m/sfw/pdf/criteria/aquaculture/mba_seafood%20watch_aquaculture%20standard_version%20a3.2.pdf?la=en

Percentage of total protein from non-edible sources (by-products, etc.)	19.46%	18.91%	21.69%	0.00%
Percentage of protein from edible sources	80.54%	81.09%	78.31%	100.00%
Percentage of protein from crop sources	70.91%	70.56%	51.4%	0.00%
Feed conversion ratio	2.3	2.0	1.7	9.0
Protein INPUT per MT of farmed fish	966 kg	880 kg	731 kg	162 kg
Protein content of whole harvested fish**	18.9%	19.2%	20.1%	20.1%
Percentage of farmed fish by-products utilized	100%	100%	100%	100%
Utilized **protein OUTPUT** per MT of farmed fish	370.2 kg	358.9 kg	306.7 kg	20.1 kg
Net protein gain or loss	-52.41%	-49.71%	-46.42%	-87.59%
Seafood Watch score (0-10)	4	5	5	1

* Average crude protein content of grower diets for each species (aggregated feed data obtained through pers. comms. with a number of feed companies, June 2019)
** Protein % of whole seabass and seabream (Nasopoulou et al. 2011) and meagre (Luten et al. 2006)

As can be noted in Table 10, the score for Factor 5.2 – Net Protein Gain or Loss is somewhat different for each of the species under consideration, although all three demonstrate a substantial net loss of protein: for seabass the final score is 4 out of 10 and for seabream and meagre it is 5 out of 10.

With regards to meagre farmed in Egypt using whole fish, the protein content of whole feed fish was assumed to be 18%, per guidance of the Seafood Watch Aquaculture Standard in the absence of specific data of whole-fish protein content for Factor 5.2. Given the eFCR of 9.0 and consideration of all feed as edible protein, the Factor 5.2 score is 1 out of 10.

Factor 5.3. Feed Footprint

This factor is an approximate measure of the global resources used to produce aquaculture feeds (i.e. the inclusion levels of marine, terrestrial crop, and terrestrial land animal feed ingredients). These calculations are based on the average global ocean and land area used for production of one MT of farmed fish.

Table 11: The parameters used and their calculated values to determine the ocean and land area appropriated by feed ingredients in the production of farmed seabass, seabream and meagre

Parameter	Seabass	Seabream	Meagre	Meagre (whole fish)
Marine ingredients inclusion	26%	27%	41%	100%
Crop ingredients inclusion	70.91%	70.56%	51.4%	0%
Land animal ingredients inclusion	3.75%	3.75%	3.75%	0%

Ocean area (hectares) used per MT of farmed fish	15.55 ha	14.04 ha	18.13 ha	64.37 ha
Land area (hectares) used per MT of farmed fish	0.71 ha	0.62 ha	0.40 ha	0.00 ha
Total global area (hectares) used per MT of farmed fish	16.26 ha	14.66 ha	18.53 ha	64.37 ha
Seafood Watch Score (0-10)	4	5	3	0

As shown in Table 11, the ocean area necessary for production of marine ingredients required to produce one MT of farmed seabass is 15.55 ha; for seabream it is 14.04 ha; and for meagre it is 18.13 ha. The land area necessary for production of terrestrial (crop and land animal) ingredients required to produce one MT of farmed seabass is 0.71 ha; for seabream it is 0.62 ha; and for meagre it is 0.4 ha. The combination of these two values results in an overall feed footprint of 16.26 ha/MT for farmed seabass; 14.66 ha/MT for farmed seabream; and 18.53 ha/MT for farmed meagre. Thus, the final score for Factor 5.3 – Feed Footprint varies somewhat between each of the three species under consideration: both seabass and seabream returned moderate scores of 4 and 5 out of 10, respectively, whereas meagre achieves a moderate-high score of 3 out of 10.

With regards to meagre farmed in Egypt using whole fish, the ocean area appropriated per each MT of farmed meagre is calculated to be 64.37 hectares, resulting in a Factor 5.3 score of 0 out of 10.

Conclusions and final score

The final score for Criterion 5 – Feed is the average of the three factor scores with a double-weighting on Factor 5.1 – Wild Fish Use. For seabass, seabream and meagre, respectively, the score for Factor 5.1 - Wild Fish Use is 6.77, 5.41, and 4.57; for Factor 5.2 - Net Protein Gain or Loss the score is 4, 5, and 5; and for Factor 5.3 - Feed Footprint the score is 4, 5 and 3. Taken together, the scores for these three factors combine to give a final Criterion 5 – Feed numerical score of 5.38, 5.21, and 4.28 out of 10 for seabass, seabream and meagre, respectively.

With regards to meagre farmed in Egypt using whole, the Factor 5.1 – Wild Fish Use score is 0 out of 10; the Factor 5.2 - Net Protein Gain or Loss score is 1 out of 10; and the Factor 5.3 - Feed Footprint score is 0 out of 10. When the scores for these three factors are added together, the final Criterion 5 – Feed score for meagre farmed in Egypt using whole fish is 0 out of 10, a Critical conservation concern, resulting in an overall Red rating and an “Avoid” recommendation.

Criterion 6: Escapes

Impact, unit of sustainability and principle

- Impact: competition, genetic loss, predation, habitat damage, spawning disruption, and other impacts on wild fish and ecosystems resulting from the escape of native, non-native and/or genetically distinct fish or other unintended species from aquaculture operations
- Sustainability unit: affected ecosystems and/or associated wild populations.
- Principle: preventing population-level impacts to wild species or other ecosystem-level impacts from farm escapes.

Criterion 6 Summary: EU & Turkey

Escape parameters	Value	Score
F6.1 System escape risk	1	
F6.1 Recapture adjustment	0	
F6.1 Final escape risk score		1
F6.2 Competitive and genetic interactions		3
C6 Escape Final Score (0-10)		**2**
Critical?	NO	**RED**

Criterion 6 Summary: Egypt

Escape parameters	Value	Score
F6.1 System escape risk	0	
F6.1 Recapture adjustment	0	
F6.1 Final escape risk score		0
F6.2 Competitive and genetic interactions		9
C6 Escape Final Score (0-10)		**5**
Critical?	NO	**YELLOW**

Brief Summary

This Criterion has been split into two separate recommendations: one for the EU and Turkey and one for Egypt. This differentiation was required due to significant regional differences in both the production systems utilized and the source of juveniles stocked.

With regard to the EU and Turkey, given the available data and the high escape risk that is inherent with open-net pen aquaculture systems, it is clear that multiple large escapes and frequent trickle losses have occurred, and continue to occur, particularly in the seabream sector, and any corrective actions have not been adequate to limit escapes. This warrants a score of 0 out of 10 for Factor 6.1. However, the implementation of published best management practices is assumed to occur to some degree, and some areas have begun implementing mandatory escape prevention practices. This then partially warrants a score of 2 out of 10, and a final intermediate score of 1 out of 10 for Factor 6.1 is given for the EU and Turkey.

While seabass and seabream are considered native throughout the geographic range encompassed by this report, this is not entirely the case for meagre, which is evidently rare or absent in the more northerly regions under consideration. In all jurisdictions, there are concerns that domesticated escapees could cause genetic drift to occur in wild populations should breeding take place between farmed and wild individuals. The ecological threat that this presents has attracted the attention of numerous research projects and much funding has been directed toward understanding the causative factors of such events and their ecological impacts, plus the development of measures to mitigate against these threats. Escape through spawning, whereby viable fertilized eggs emanate from cages, is also feasible, although this is reportedly rare and is typically only associated with cultured seabream, not with seabass or meagre. Selective breeding in aquaculture, which favors traits such as fast growth, appealing morphology and disease resistance, inevitably results in loss of genetic diversity within farmed stocks. Studies show that phenotypic variation exists between wild and farmed seabass, seabream and meagre, and also indicate that some genetic introgression has occurred, resulting in a score of 3 out of 10 for Factor 6.2 Competitive and Genetic Interactions: EU & Turkey. When the scores for these two factors are combined, the final score assessed for Criterion 6: Escapes - EU & Turkey is 2 out of 10.

In Egypt, culture of seabass, seabream and meagre primarily occurs in earthen ponds, which are located between +3 and -1 meters above sea level. Although limited data on aquaculture escapes were identified, it is evident that winter storms and floods are increasingly common in the region and these weather conditions inevitably facilitate escape events from ponds located in this flood prone area. Factor 6.1 Escape Risk: Egypt scores 0 out of 10. However, since juveniles are typically wild-sourced from local fisheries, escaped individuals pose a low concern in terms of competitive and genetic interactions with wild conspecifics and this results in a score of 9 out of 10 for Factor 6.2 Invasiveness: Egypt. When these factors are combined, the final numerical score for Criterion 6: Escapes – Egypt is 5 out of 10.

Justification of Rating

This criterion combines two factors; Factor 6.1 assesses the risk of escapes from a typical farm based on characteristics of the production system used whereas Factor 6.2 assesses the potential for competitive and genetic interactions and impacts due to the presence of escaped species. The potential for interbreeding between farmed fish and wild conspecifics is a cause for concern due to the impact that this may have upon genetic diversity. Aside from genetic impacts, escapees may impact populations of wild fish by causing competition for prey and habitat. Since culture of the species under assessment predominantly takes place in brackish ponds in Egypt and in ocean cages in the EU and Turkey – and also because the former typically relies on wild-caught juveniles whereas the latter is supplied by hatcheries – this Criterion is assessed separately for both regions.

Factor 6.1 Escape risk: EU & Turkey

Due to the open nature of net-pens, it is inevitable that escape events will occur from time to time. Escapes may arise from a variety of circumstances, such as inclement weather, poor handling, human error, equipment failure, or from predator damage to nets. 'Escape through spawning' also poses a threat; some species of fish can attain sexual maturity in cages during on-growing, and thus they have the potential to disperse viable, fertilized, domesticated eggs into the natural environment (SEP 2015, Sanchez-Jerez 2013). Although this has been documented in seabream cages, such incidents are reportedly rare (pers. comm. Anna Toffan, DVM, PhD., November 2019). One Greek study that focused on this topic concluded that: "*Whilst we documented low daily survival rates of fertilized eggs in the vicinity of sea-cages, our findings imply that the escape of eggs from sea bream farms may have ecological consequences, which likely depend on the sex ratio and intensity of farming within specific regions.*" (Somarakis et al. 2013). Escape through spawning is not associated with meagre culture (PreventEscape 2013) and is unlikely to occur with seabass under normal farming conditions, since they are generally harvested before reaching maturity (Brown et al. 2015).

Due to a lack of reliable data on escapes, it is challenging to accurately assess the escape risk of farms across the sector, but a number of regional studies give some useful insights. One study by Brown et al. (2015), which took place in Cyprus, sought to determine the prevalence and survival of seabass escapees from farms by using microsatellite markers; this was conducted in 2012 and 2013 and was the first study of its kind in the region. At the end of the study period, the aggregated average percentage of escapees detected at sampling sites was 15%, a quantity closely aligned with a similar study in the Adriatic, which detected that 14% of fish sampled were escapees (Šegvić-Bubić et al. 2017). However, as Brown et al. elucidate, this average percentage was heavily influenced by a number of targeted sampling sites, all of which were within 10 kilometers of each other and which transpired to be areas where recent escapees tended to congregate, kept together by their innate shoaling behavior. When these sites were removed from the calculation, the average percentage of escapees caught elsewhere was reduced to 4%. Of additional note, the majority of escapees caught were between 300-500 g, indicating that they were recent farm escapes (Brown et al. 2015).

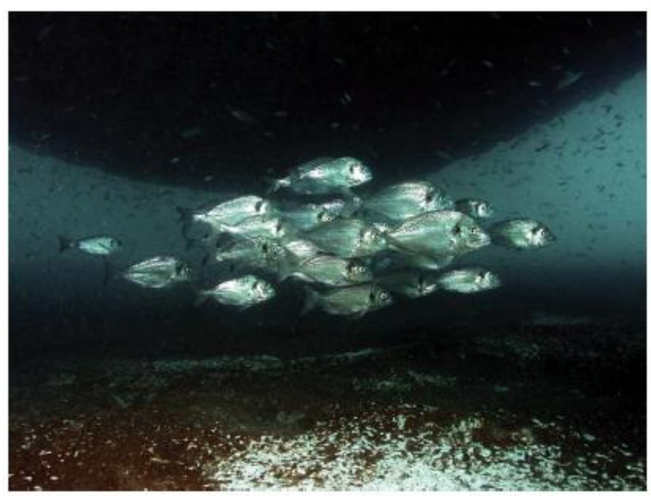


Figure 16: Recently escaped farmed seabream in a shoal formation below an ocean cage - picture taken by Arturo Boyra, Oceanografica © (Arechavala-Lopez et al. 2017a)

Concerning meagre, Sanchez-Jerez (2013) comments that in south-eastern Spain, prior to meagre culture commencing in the vicinity, this species had not been caught by local fishermen for over 100 years and was considered extinct in the region, whereas now it is a relatively common component of their catch.

An EU-funded project, entitled ‘Prevent Escape’ (PreventEscape 2013), ran for three years between 2009 and 2012 with the goal of “*Assessing the causes and developing measures to prevent the escape of fish from sea-cage aquaculture*”. Literature generated by the project noted that while there were no statistics available documenting the extent of Mediterranean aquaculture escapes, since the region does not have such reporting requirements in place, it was evident from insurance claims that such incidents make up a sizeable component of reported losses and result in significant economic impacts. Over seven million fish (a combination of seabream, seabass, meagre) escaped over the study period (2009-2012) with seabream escapes accounting for nearly 90% of escapees, with structural failures being cited as the most significant causative factor (Jackson et al. 2015). Figure 17 quantifies the escape incidents of seabream, seabass and meagre during the three-year study period and Figure 18 categorizes the causes of these events. These data were obtained from countries in the project’s scope via questionnaires.

	No. of sites per species from questionnaires	Escape incidents	No. of fish escaped over 3 years	Escapes per annum	2007 price/kg	Nominal cost (500 g)	No. of sites	% overall sites	Nominal cost of lost annual production	Total value of production (million €) 2007
Spain	24	15 Bream	5,849,000	1,949,666	€4.30	€4,191,781	111	21%	€19,960,861	95.5
	25	2 Bass	520,000	173,333	€4.98	€431,599	108	23%	€1,876,521	52.2
	3	1 Meagre	200,000	66,666			30	10%		
Greece[a]	6	15 Bream	909,200	303,066	€3.57	€540,972	210	2.8%	19,320,428	282
	5	9 Bass	65,100	21,700	€5.12	€55,552	130	3.8%	€1,461,894	245.7
Malta	3	22 Bream	87,900	29,300	€4.33	€63,434	4	75%	€84,579	4.8
	2	4 Bass	14,500	4833	€14.71	€35,546	3	67%	€53,053	1.1
								Total	€42,757,336	

Figure 17: Cultured fish losses in Spain, Greece and Malta – 500g market size average for both seabream and seabass (Figure reproduced from Jackson et al. 2015)

Species	Total		Structural		Biological		Operational		External		Unknown	
	No. of incidents	No. of escapes	No. of incidents	No. of escapes	No. of incidents	No. of escapes	No. of incidents	No. of escapes	No. of incidents	No. of escapes	No. of incidents	No. of escapes
Atlantic Salmon	113	820,158	40	678,279	5	6758	47	88,065	3	13,194	18	33,862
Cod	61	457,005	6	16,466	38	118,974	6	11,839	3	180,717	8	129,009
Sea bass	15	599,600	9	540,000	5	52,100			1	7500		
Sea bream	52	684,6100	22	6,181,900	25	604,000	1	20,000	2	25,200	2	15,000
Meagre	1	200,000	1	200,000								
Totals	242	892,2863	78	7,616,645	73	781,832	54	119,904	9	226,611	28	177,871

Figure 18: Causes of escape incidents and numbers of escaped fish as identified by ‘Prevent Escape’ project questionnaire (Figure reproduced from Jackson et al. 2015)

As can be noted in Figure 18, when the number of seabream, seabass and meagre escapees are considered together, the vast majority of escapes were seabream (almost 90%) with much smaller quantities of seabass (just under 8%) and meagre (just under 3%). Although the study data included a number of catastrophic escape incidents involving seabream, it is relevant to note that seabream have a behavioral trait of nibbling on the net, which allows holes to develop, and net biting was identified as the biggest cause of escapes during the study period. Although seabass do not share this trait, they are apparently more opportunistic at identifying escape routes (Arechavala-Lopez et al. 2017a).

Interactions	Implications and risks	Sps.	Geographic area/s	H	Author/s.
Ecological	Dispersion, competition, predation	Br	W-Mediterranean	D/S	Arechavala-Lopez et al., 2012a
		Br	C-Mediterranean	D/S	Šegvić-Bubić et al., 2017b
		Bs	W-Mediterranean	D/S	Arechavala-Lopez et al., 2014a
	Establishment/local-absent sps.	Br	CE-Atlantic	D/S	González-Lorenzo et al., 2005
		Bs	CE-Atlantic	D/S	Toledo-Guedes et al., 2009,2012
		Bs	CE-Atlantic	D	Toledo-Guedes et al., 2014a,b
		Bs	CE-Atlantic	D/S	Ramirez et al., 2015
	Pathogens transmission	Br	W-Mediterranean	S	Arechavala-Lopez et al., 2012a
		Bs	W-Mediterranean	S	Arechavala-Lopez et al., 2011
		Bs	CE-Atlantic	S	Toledo-Guedes et al., 2012
		Br, Bs	Mediterranean Sea	S	Arechavala-Lopez et al., 2013a
	Interbreed, hybridization, etc.	Br	C-Mediterranean	S	De Innocentiis et al., 2004
		Br	Mediterranean and NE-Atlantic	S	Miggiano et al., 2005
		Br	C-Mediterranean	S	Šegvić-Bubić et al., 2011a
		Br	C-Mediterranean and NE-Atlantic	S	Franchini et al., 2012
		Br	C-Mediterranean	D	Šegvić-Bubić et al., 2014
		Bs	Mediterranean	S	Bahri-Sfar et al., 2005
		Bs	Mediterranean and NE-Atlantic	S	Haffray et al., 2006
		Bs	E-Mediterranean	S	Brown et al., 2015
		Bs	C-Mediterranean	D	Šegvić-Bubić et al., 2017a
	Gametes/eggs escapes	Br	E-Mediterranean	S	Dimitriou et al., 2007
		Br	C-Mediterranean	S	Šegvić-Bubić et al., 2011a
		Br	C-Mediterranean	S	Franchini et al., 2012
		Br	E-Mediterranean	D	Somarakis et al., 2013
Socioeconomic	Farm economic losses	Br, Bs	Mediterranean	D	Jackson et al., 2014
	Impacts on fish/mussel farms	Br	C-Mediterranean	D	Šegvić-Bubić et al., 2011b
	Interactions with fisheries	Br	E-Mediterranean	D	Dimitriou et al., 2007
		Br	W-Mediterranean	D	Arechavala-Lopez et al., 2012a,2018
		Br	W-Mediterranean	D	Izquierdo-Gómez et al., 2014,2017
		Br	W-Mediterranean	S	Izquierdo-Gómez et al., 2016
		Bs	W-Mediterranean	D	Arechavala-Lopez et al., 2011,2018
		Bs	CE-Atlantic	D	Toledo-Guedes et al., 2014a,b

Figure 19: A summary of literature investigating the genetic, ecological and socioeconomic implications and risks of escaped farmed seabream (Br) and seabass (Bs) - H: hypothesis, S: suggested; D: demonstrated (Figure reproduced from Arechavala-Lopez et al. 2017a)

A recent review of the seabream and seabass sector, which assessed the risks and related implications of escapes from farms, compiled a table of literature on the topic: this is shown in Figure 19. The authors of this review highlighted the fact that, "*None of the Mediterranean aquaculture legal frameworks encompass the management of fish escapes whatsoever.*" (Arechavala-Lopez et al. 2017a). In addition to identifying this gap in governance of the sector, the authors note that fish farm workers in the region are often not given formal guidance in escape prevention and mitigation, and that this should be incorporated into mandatory best practice training for staff. The report also identifies a number of resources that are available to assist in disseminating codes of best practice, such as the FAO's guidelines on cage deployment and management, which provides specific measures to prevent escapes (Cardia & Lovatelli 2007), and the IUCN Marine Programme guidelines, published in 2007 and 2009 (Arechavala-Lopez et al. 2017a, IUCN 2007, IUCN 2009). The first guide focuses on interactions that occur between aquaculture and the environment and includes guidance on escape management related to system design, escape contingency plans, and additional prevention measures during high risk activities (e.g. grading, moving, or harvesting fish). According to a recent EU-funded study these IUCN guidelines have now been incorporated into aquaculture planning at the national level across the region and legally adopted by Croatia, Italy, Spain and Turkey

(AquaSpace 2018b). The Federation of European Aquaculture Producers[93] (FEAP) also have a Code of Conduct which states:

- Farmers will seek to minimise the potential risks that are presented by farmed fish escapes to wild fisheries.
- Farmers will, in the event of escapes, co-operate and inform the respective authorities to assure that appropriate actions will be taken.

Other examples of the dissemination of best practice guidelines to the industry were two guides produced as the result of the EscaFEP (Prevention and mitigation of escapes in aquaculture) Project, an initiative funded by the EU's European Fisheries Fund (EFF)[94]. These guides aimed to facilitate and increase the ongoing training of aquaculture personnel working with floating cage facilities with the goal of reducing escapes. The first guide (Izquierdo-Gómez et al. 2014b) identifies the critical points that arise during routine on-growing when escape events are most likely to happen; it then goes on to explain preventative measures that can be implemented to avoid these occurrences, such as during net changes and fish transfers. This guide also highlights the importance of appropriate site selection and covers cage deployment and mooring, plus the maintenance of nets and associated equipment, in some detail. This document further comments that escapes should be monitored and reported, both within the company and at the administrative level, in order that such incidents can be better understood, and prevention measures improved. The second guide (Izquierdo-Gómez et al. 2014b) comments that while existing management measures emphasize the need to prevent escapes through implementation of good practices and the use of cage equipment that meets rigorous quality standards, there is a pressing need for legislative controls to be developed to govern this aspect of production and that these need to include penalties for non-compliance.

While the various guidelines mentioned above have been utilized in workshops and company training sessions, it is impossible to quantify their commercial implementation, since there is no legal requirement to document or implement such measures. Of note, the Canary Islands, which are located in Spanish Atlantic waters, have very recently adopted a new "*Protocol for the prevention and mitigation of fish escapes from sea cages in the open sea*". Adherence to this Protocol is now mandatory for all farms in the region since it was passed in 2018. Across the sector, this is the first such regulation to be implemented that specifically and explicitly addresses the management of escapes (pers. comm. P. Arechavala-Lopez, PhD., June 2019). In addition to this, communications with a Greek aquaculture expert confirms that best managements practices for escape prevention are routinely implemented by farmers here. These measures include regular, scheduled dive inspections of moorings, nets and pens during which any maintenance or repairs are actioned and recorded. Additionally, fish counters are employed to facilitate accurate fish counts during fish movements and durable, high strength

[93] http://feap.info
[94] https://ec.europa.eu/fisheries/cfp/eff_en

netting (Dyneema®[95]) is employed by farmers, which is particularly effective at preventing damage incurred by fish bites (pers. comm. John A. Theodorou, PhD., December 2019).

Given the available data and the high escape risk that is inherent with open-net pen aquaculture systems, it is clear that multiple large escapes and frequent trickle losses have and continue to occur, particularly in the seabream sector, and any corrective actions have not been adequate to eliminate escapes. This warrants a score of 0 out of 10 for Factor 6.1. However, the implementation of published best management practices evidently occurs to some degree, and some areas have begun implementing mandatory escape prevention practices. This then partially warrants a score of 2 out of 10, and a final intermediate score of 1 out of 10 for Factor 6.1 is given for the EU and Turkey. The Seafood Watch Aquaculture Standard allows for this score to be adjusted in instances where there is evidence of re-capture occurring and this is reviewed in more detail below.

Re-Capture Efforts

Šegvić-Bubić et al. (2018) comment that in the Mediterranean, "*Escape reporting is still not mandatory for farmers, though the legislation stipulates the right of the farmer to recapture fish within the farming concession following a request to do so. In practice, permissions for fish recapture are rarely requested.*" In addition to farmer's attempts to re-capture escaped stock, these fish may also be captured by recreational fishers, given the sizeable recreational fishery in the region (Hyder et al. 2017). One study that was part of the 'Prevent Escape' project noted that recreational fishing efforts were higher around fish farms in the Mediterranean in comparison to near-by areas without farms, as was the presence of predatory wild fish, and that escaped seabass and seabream, even when not captured, had a high mortality rate - though this was not quantified (Arechavala-Lopez et al. 2011). However, it is also evident that sometimes escapees do manage to assimilate into the wild successfully, even attaining similar longevity to their wild counterparts (Arechavala-Lopez et al. 2017a).

In order to help formulate contingency plans for the industry, a recent Spanish study simulated a number of escape events at different coastal fish farms. Three separate localities were used for the escape simulations; each farm released either meagre, seabream or seabass and, in each instance, a total of 1000 tagged fish 'escaped'. To recreate as genuine a scenario as possible, and to avoid an abnormally large fishing effort, only local fishermen were informed in a timely way about the 'escape' and asked to report landings of tagged individuals, including location, fishing method and date. From this information, the data in Figure 20 was compiled.

[95] https://www.dsm.com/products/dyneema/en_GB/applications/nets/aquaculture-nets.html

Species	Location	N fish released	Mean W ± SE	Exp. Fishing (T)		Recreational (U1)		Artisanal (U2)		Recapture rate (%)	
				N	CPUE*	Angling	Spear	Nets	Traps	T	T+U1+U2
Sea bass	Málaga	1000	131 ± 15	0	0	46	8	0	–	0	5.4
Sea bream	Almería	1000	122 ± 27	8	1.33	30	4	29	–	0.8	7.1
Meagre	Águilas	1000	143 ± 18	38	2.64	1	0	47	1	3.8	8.7

Figure 20 : Number of recaptured fish, mean weight in grams (±Standard error; SE) and recapture rates obtained by experimental fishing (T: targeted fishing) and untargeted fishing (U1: recreational; U2: artisanal) by type of gear. *CPUE refers to the number of captured individuals per 100 m^2 of net (Arechavala-Lopez et al. 2018)

As can be noted in Figure 20, 8.7% of meagre were documented as having been re-captured, 7.1% seabream and 5.4% seabass. The study also showed that each of these three species vary in their post-escape behavior and that successful re-capture methods vary between species, with the time that has elapsed since the escape event and the distance from the farm being of great relevance. Previous studies on the recapture of escaped farmed seabream in the region demonstrated similar success rates ranging from 7.1% (Arechavala-Lopez et al. 2012), 6.3% and 11.2% (Santos et al. 2006, Sánchez-Lamadrid 2004, Sánchez-Lamadrid 2002). A study in the western Mediterranean Sea had a lower rate of success in recapturing seabass (1.3%) although this may have been due to the inefficacy of the specific techniques employed by participating recreational fishers (Arechavala Lopez et al. 2014), since a study conducted further west, off the Canary Islands, realized a re-capture rate of 22.2% following a large seabass escape event caused by a storm. Professional fishermen reportedly used a wide range of techniques to catch the escapees (Toledo-Guedes et al. 2014). Similar studies on escaped farmed meagre indicate that this species exhibits little site fidelity post-escape and that re-capture efforts must be implemented within 24 hours of the escape event in order to have any degree of success (Arechavala-Lopez et al. 2017b, Arechavala-Lopez et al. 2015). Of note, the FAO species profile on meagre comments that: "*Recently a few hundred meagre escaped from a cage in Tuscany but all were collected nearby within a few days by the local trawling fleet, indicating that this species does not move very fast and is easily recaptured; this reduces the risk of altering the existing fish community structure,*"(FAO 2005-2018b).

Another study that reviewed escapes from Spanish coastal farms concluded that trickle losses may have an overall greater environmental impact than single, large escape events due to the fact that the latter is more likely to stimulate greater fishing efforts by recreational and artisanal fishers, which in turn increases the likelihood of successful recapture (Izquierdo-Gómez, et al. 2016).

Despite literature and anecdotal evidence that suggests escapees are commonly caught by recreational and commercial fishers, it appears that recaptures totalling <10% of escaped stock are the norm. Therefore, no scoring adjustment is applied, and the final Factor 6.1 Escape Risk Score, as it pertains to the EU & Turkey, is 1 out of 10.

Factor 6.1 Escape risk: Egypt

Damietta Governorate, which is located in the northeast of the Nile delta on the southern Mediterranean coast, is where 91% of seabass, seabream and meagre production takes place (GAFRD 2018b), particularly in the area known as the Deeba Triangle, which is located in the north-western part of Lake Manzala (El-Mezayen et al. 2018, USDA FAS 2016, Abdelhamid et al. 2013, FAO 2010). The balance of production comes from the neighboring governorates of Port Said, Alexandria and Suez. While no specific data on aquaculture escapes or the implementation of escape prevention measures were identified, it is evident that winter storms and floods are increasingly common (Guardian 2017) in this highly productive mariculture region and that these weather conditions inevitably facilitate escape events.

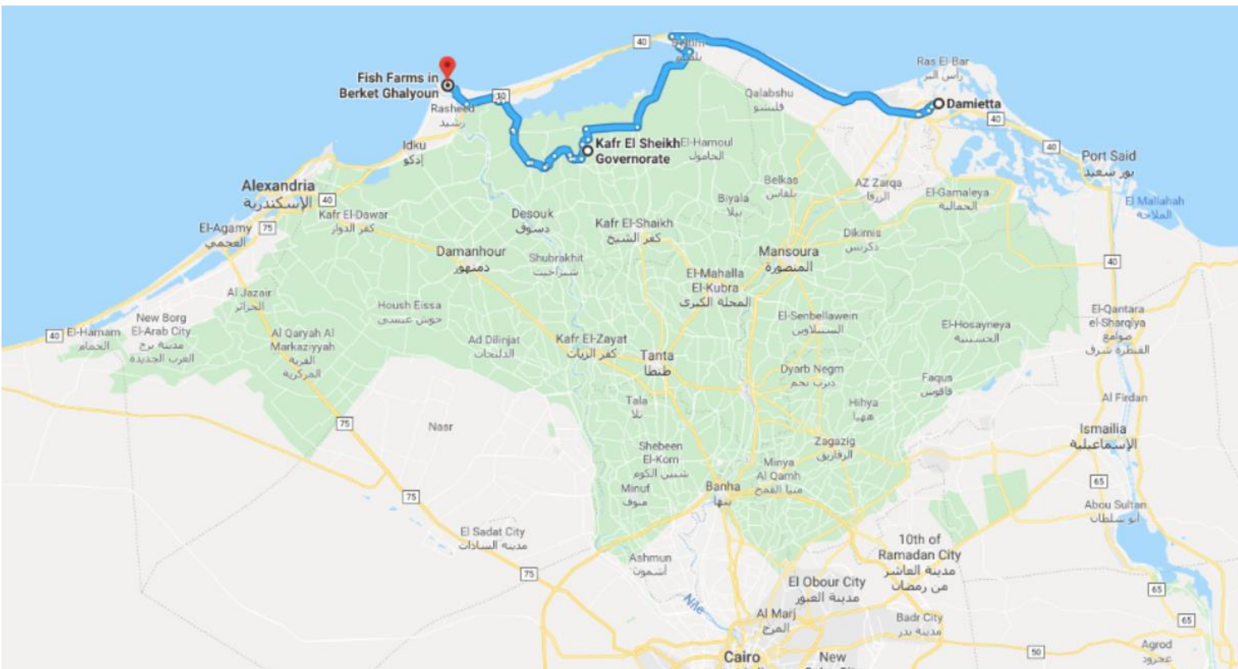


Figure 14: Map of the Egyptian Nile River Delta and Mediterranean coast showing the relative locations of Damietta, Port Said, Kafr El Sheikh, Berket Ghalyoun and Alexandria (Google Maps, 2019, maps.google.com)

In December 2018, a state of emergency was declared after a major flooding event inundated the coast of Kafr El Sheikh Governate (Al-Monitor 2018). Coastal protection projects are being implemented in the governate, including the coast north of Berket Ghalyoun, where a new large-scale fish farm development is underway (Feidi 2018). In addition to the coastal protection project underway in Kafr El Sheikh, the governates of Damietta and Alexandria are also implementing flood protection measures to shield Egypt's Mediterranean coast from the effects of rising sea levels and storm surge (Al-Monitor 2018).

While new flood protection measures are encouraging, fish escapes from storm and flood events have been reported in the past; El-Mezayen et al. (2018) comment that fish escaped from coastal ponds after storms damaged irrigation gates of the farms in 2015. The Nile delta's coastal zone is low lying, ranging between +3 and -1 meters above sea level (IDRC 2012) and the region is particularly vulnerable to climate change impacts (Soliman 2017, Masria et al. 2014). In 2011, the government released a report which estimated that around 13% of the northern coastline is at risk from the Mediterranean's rising sea levels (UNDP 2011). A recent FAO report specifically notes that coastal fish ponds may be prone to flooding due to climate change (FAO, 2017b).

Without any evidence that escape prevention measures are implemented on farms, and in consideration of the fact that seabream, seabass and meagre farms are located in flood-prone areas, the risk of escape events occurring as a result of flooding is assessed to be high and the Factor 6.1 Escape Risk Score, as it pertains to Egypt, is 0 out of 10.

Factor 6.2 Competitive and genetic interactions: EU & Turkey

Factor 6.2 is a trait-based measure of the likelihood of genetic and/or ecological disturbance from escapees based on their native or non-native status, and/or their domestication and ecological characteristics. While seabass and seabream are considered native throughout the entire culture range of the scope of this report, this is not entirely the case for meagre, which is reportedly rare or absent in northern Mediterranean counties (Abou-shabana et al. 2012) and has become uncommon off Croatia's Adriatic coast (Kružić 2016).

It is evident that farmed specimens of each species do display a variety of phenotypic variations from wild conspecifics (Šegvić-Bubić et al. 2017, Saavedra et al. 2017, Šegvić-Bubić et al. 2014). In addition to the potential for negative genetic impacts, escapes pose a further ecological threat in term of competition for resources and space. Despite the aforementioned research indicating high mortality rates of escaped seabass and seabream, other researchers have identified escapees that have evidently adapted successfully and have survived in the wild (Arechavala-Lopez et al. 2017a), including the observation by one author of two large females with mature eggs, which clearly demonstrates that these fish can survive and do have the potential to breed outside of captivity (Brown et al. 2015).

Data and research regarding the potential impacts of meagre escapes is generally less abundant than that pertaining to the escapes of farmed seabass and seabream. The quantity of farmed meagre produced, thus far, is much smaller than that of seabass and seabream and its timeline of domestication is much shorter. The FAO species profile on meagre notes that they are endemic throughout the Mediterranean and that their range continues far down the west coast of Africa to the bay of Dakar off Senegal (FAO 2005-2018b), although, as noted above, meagre are evidently uncommon or absent in the northern Mediterranean. Despite regional variation in distribution and abundance, the FAO meagre profile further states that farmed escapees are generally not considered a risk, given their endemic status in the Mediterranean (FAO 2005-2018b). Experts note that while the introduction of exotic species is covered by aquaculture legislation in the EU, the farming of species which are locally absent or extinct, as is evidently the case with meagre in some localities, is not factored into the existing legal framework (pers. comm. P. Arechavala-Lopez, PhD., June 2019). In such regions, any escapes of farmed meagre from aquaculture operations would constitute the introduction of a new species into the ecosystem (pers. comm. Dr. Pablo Arechavala-Lopez, November 2019).

<u>Hatchery domestication and breeding programs</u>

In comparison to meagre, the genetic impacts of escaped seabass and seabream are potentially higher since these species have been farmed for longer and their domestication is therefore somewhat more advanced. In practice, there is often no specific selection of broodstock implemented in seabass and seabream hatcheries, but broodfish are generally aquaculture-raised and wild genetic inputs are limited to the occasional addition of a few wild broodstock (if at all) to avoid inbreeding (pers. comm. Donatella Crosetti, PhD., April 2019). As is discussed further in Criterion 8X, a number of seabass and seabream hatcheries also produce fry using selective breeding programs, which endeavor to artificially select for desirable traits, such as rapid growth, adaptation to the farm environment, improved yield, and disease-resistance (Chavanne et al. 2016). The longest lineage of domesticated seabass in 2016 was eight generations distant from the original wild population, though broadly, domestication of seabass is still considered in the onset, with roughly 50% of farmed seabass originating from selective breeding programs (Vandeputte et al. 2019); this echoes the estimation of Janssen et al. (2016), which puts the number at around 43-56%. With regard to seabream, there are evidently "*Very few 'real' long-term breeding programmes*" for this species (pers. comm. Donatella Crosetti, PhD., April 2019), although such programs are evidently in development: Janssen et al (2016) note that commercial breeding programs for seabream were initiated in the 2000s and these endeavors presently account for around 60-66% seabream production.

	Growth	Morphology	Disease resistance	Processing yield	Product quality	Maturity, fecundity	Feed efficiency[a]
Sea bream	6	4	2	0	2	0	1
Sea bass	6	4	1	2	1	1	1
Turbot	2	0	1	0	0	0	0
Rainbow trout	10	8	5	5	3	5	2
Salmon	7	3	7	6	6	2	2
Carp	4	4	2	1	0	1	0
All species	35	23	18	14	12	9	6

[a] Indirect genetic selection response assumed

Figure 22: The main genetic traits targeted by selective breeding programs in a variety of European aquaculture species, as identified in a comprehensive survey* (Chavanne et al. 2016)
*Note that this survey of breeding companies included 4 named producers of gilthead seabream in Greece and Spain and also four named producers of European seabass in France, Turkey and Greece, however, the authors of the study comment that other participants requested to remain anonymous

Figure 22, which features data from a survey of European aquaculture breeding programs, shows that the most commonly strived for genetic trait in the target species is, unsurprisingly, fast growth, closely followed by desirable morphology characteristics and disease resistance. Novel selective breeding strategies have also emerged, which use molecular tools to allow genomic selection of broodfish. The risk of progressive genetic erosion that such domestication strategies present, should farmed fish escape and admix their homogenized gene set with that of wild conspecifics, has prompted considerable research into this topic (Chavanne et al. 2016).

Research efforts into competitive and genetic interactions

Numerous studies have been conducted to quantify and analyze the genetic impacts of escaped farmed seabass and seabream. To accomplish this, a variety of techniques have been employed to identify escapees in the wild, such as morphology, scale and otolith analysis, fatty acid analysis, microsatellite DNA markers and mitochondrial DNA markers. The most effective of these are the genetic tools, since they are not subject to environmental influences (Brown et al. 2015).

Prior to the 'Prevent Escape' project, the EU funded a related initiative called 'Genimpact'; commencing in 2005, its objective was to "*Review and discuss the current knowledge about the genetic impacts of farming activities and their implications for aquaculture management, stock conservation and environment safety, and to integrate the scientific basis for the establishment of preventive measures, for important aquaculture species*," (Genimpact 2005). This formative project identified numerous knowledge gaps with regards to seabass and seabream, concluding that further genetic analysis of wild populations of both species was needed across their range, particularly in the eastern Mediterranean Sea where cultured production was highest. Genimpact researchers concluded further that more work was required to assess the impacts of domestication on the fitness of cultured fish and how this may affect their ability to survive in the wild and breed and highlighted the potential genetic risk posed by the transfer of broodstock, juveniles, eggs and larvae across geographical distances (Svåsand et al. 2007). A number of similar EU-funded projects have subsequently followed on from this initiative and at present the AquaTrace[96] project, which seeks to detect and address the magnitude of interbreeding between farmed fish and wild conspecifics, is underway. It is important to note that Genimpact (2005) also indicated that there are two genetically distinct wild stocks of seabream and three of seabass, while describing the impact of hatchery restocking programs on reducing the differentiation between the two wild seabream stocks; this indicates that some degree of genetic impact, unrelated to aquaculture escapes, has already occurred.

Although seabream is native throughout the range of the scope of this report, farmers of this species in the EU and Turkey have traditionally favored Atlantic-sourced broodstock, due to the good growth characteristics they exhibit (Grigorakia & Rigos 2011). A similar strategy has also been employed by the seabass sector in this region, with broodfish usually being comprised of Atlantic and Western Mediterranean stocks (Grigorakia & Rigos 2011). This has resulted in a predominant eastward movement of stocks, in terms of the broodstock, eggs and juveniles that supply hatcheries and farms (Svåsand et al. 2007).

[96] https://fishreg.jrc.ec.europa.eu/web/aquatrace/about-aquatrace

One Spanish study noted that wild seabream caught close to fish farms demonstrated different morphological characteristics to those caught further away indicating a high likelihood that genetic introgression had been occurring between wild and farmed fish (Izquierdo-Gomez et al. 2017). Another recent morphological study of seabream noted that farmed fish tend to have smaller heads and stockier bodies than wild conspecifics (Talijančić et al. 2017). A separate study, which set out to differentiate wild from farmed seabream by implementing both molecular and morphological methods, concluded that while morphological differences were evident, and a useful tool to tell the two groups apart (e.g. wild fish are more slender while farmed are more stocky), analysis of microsatellite markers identified a "*weak neutral genetic differentiation*" between each group. The authors further commented that morphological differences between wild and farmed specimens could be attributed to the different environment factors and feeding regimens that either group had been influenced by (Šegvić-Bubić et al. 2014). Similarly, a study in Greece, which analyzed wild seabream DNA samples collected from eight different locations along the coast at varying proximities to farms culturing this species - and then repeated this 7-9 years later - found genetic stability in wild stocks, despite numerous escape events having been reported from farms in the region (Gkagkavouzis et al. 2019). A study on seabass, however, noted localized evidence of introgression of wild stocks by domesticated genomes in the Adriatic Sea; the authors concluded: "*Our results indicate that farmed seabass successfully introgress and change the genetic profiles of some wild populations*," (Šegvić-Bubić et al. 2017).

Overall, it is apparent that farmed seabass, seabream, and meagre demonstrate phenotypic variation from their wild conspecifics, and >50% of farmed stock is sourced from hatcheries where at least some degree of selection/domestication (e.g. hatchery raised for three or more generations) has occurred, warranting a score of 4 out of 10. There is additional evidence indicating that genetic introgression of wild populations has occurred, and the potential for further introgression exists, warranting a score of 2 out of 10. Thus, the final score for Factor 6.2 – Competitive and genetic interactions: EU & Turkey is 3 out of 10.

Factor 6.2 Competitive and genetic interactions: Egypt

Seabass, seabream and meagre are all indigenous to the areas in which they are cultured in Egypt (El Sayed & Karachle 2017, EgyptToday 2017). In contrast to production in EU and Turkey, and as is explored in further detail in Criterion 8X: Source of Stock, juveniles for the Egyptian sector are almost entirely wild-caught (a score of 10 out of 10 for Factor 6.2), with roughly 15% of farm stocks being produced in hatcheries using wild broodstock (a score of 8 out of 10 for Factor 6.2) (Abdelhamid et al. 2013, El-Gamal 2018). Accordingly, the risk of negative competitive and genetic interactions arising from farm escapes and their subsequent impact upon wild conspecifics is considered to be very low. This results in an intermediate Factor 6.2 Invasiveness: Egypt score of 9 out of 10.

Conclusions and final score

Since production of these species predominantly takes place in brackish ponds in Egypt and in ocean cages in the EU and Turkey – and also because the former typically relies on wild-caught juveniles whereas the latter is supplied by hatcheries – this Criterion is assessed separately for both regions.

The open-net cage systems used in the EU and Turkey inherently present a high risk of escape events occurring, due to the likelihood of ongoing trickle losses and documented multiple large escape events. Additionally, while much work has been done to compile and disseminate guidance on best management practices to the industry, it is not possible to quantify the success of such initiatives in mitigating the incidence of escapes which, given their continued occurrence, are considered a high concern. The score for Factor 6.1 Escape Risk: EU & Turkey is 1 out of 10. Studies show that phenotypic variation exists between wild and farmed seabass, seabream and meagre, and also indicate that some genetic introgression has occurred, resulting in an outcome of 3 out of 10 for Factor 6.2 Competitive and Genetic Interactions: EU & Turkey. When the scores for these two factors are combined, the final score assessed for Criterion 6: Escapes - EU & Turkey is 2 out of 10.

In Egypt, culture of seabass, seabream and meagre primarily occurs in earthen ponds, which are located between +3 and -1 meters above sea level. Although limited data on aquaculture escapes were identified, it is evident that winter storms and floods are increasingly common in the region and these weather conditions inevitably facilitate escape events from ponds located in this flood prone area. Factor 6.1 Escape Risk: Egypt scores 0 out of 10. However, since juveniles are typically wild-sourced from local fisheries, escaped individuals pose a low concern in terms of competitive and genetic interactions with wild conspecifics and this results in a score of 9 out of 10 for Factor 6.2 Invasiveness: Egypt. When these factors are combined, the final numerical score for Criterion 6: Escapes – Egypt is 5 out of 10.

Criterion 7: Disease; pathogen and parasite interactions

Impact, unit of sustainability and principle

- Impact: amplification of local pathogens and parasites on fish farms and their retransmission to local wild species that share the same water body
- Sustainability unit: wild populations susceptible to elevated levels of pathogens and parasites.
- Principle: preventing population-level impacts to wild species through the amplification and retransmission, or increased virulence of pathogens or parasites.

Criterion 7 Summary: EU & Turkey

Disease Risk-based assessment

Pathogen and parasite parameters	Score	
C7 Disease Score (0-10)	4	
Critical?	NO	YELLOW

Criterion 7 Summary: Egypt

Disease Risk-based assessment

Pathogen and parasite parameters	Score	
C7 Disease Score (0-10)	2	
Critical?	NO	RED

Brief Summary

This Criterion has been split into two separate recommendations: one for the EU and Turkey and one for Egypt.

While there is relatively sparse documentation of disease transmission occurring between wild and farmed fish within the EU and Turkey, it appears likely that a dynamic and perpetual circulation of pathogens and parasites is ongoing, since net pen systems are open to their surroundings and consistently exchanging water with the surrounding environment. A review of literature on the sector indicates that both policy makers and farmers have greatly increased their awareness of disease issues in recent years, although it is hard to quantify the degree to which biosecurity measures (e.g. disinfection of equipment, use of certified disease-free fry, etc.) intended to stem the transmission of disease are implemented. Vaccination, which is recognized as one of the most efficient forms of disease prevention, is now a routine procedure on the majority of farms; this has undoubtedly done much to mitigate the spread of pathogens. However, although significant mortality events are notifiable by law in either jurisdiction, it does not appear that routine monitoring and reporting of disease incidence and/or mortality is legally required by any regulatory body. Recent survey data indicates that the average disease-related mortality rate for seabass and seabream farmed in the EU and Turkey is around 10% of the total fish stocked post hatchery; the total mortality rate is 15 – 20%, indicating that 50% of mortalities are attributable to disease. It is clear that some disease-related mortalities occur on farms, and though there are a number of biosecurity protocols in place, their implementation varies. Given the openness of net pens, the production system is open to the introduction and discharge of pathogens and parasites. This results in a moderate score of 4 out of 10 for Criterion 7: Disease - EU & Turkey.

There is not a great deal of literature detailing diseases impacting mariculture in Egypt, yet it is evident that numerous bacterial and parasitic diseases hamper the sector and cause mortalities in these flow through pond systems, which are open to the environment. Data on viruses is notably absent and no studies were identified that address the potential of on-farm diseases to become amplified and retransmitted to local wild species sharing the same water body. In light of a deficiency of data to robustly inform this Criterion, and because disease control systems, regulations, and management measures largely do not exist - and where they do, their implementation and enforcement is unknown and/or ineffective - the potential ecological risk of the sector is assessed to be moderately high which results in a score of 2 out of 10 for Criterion 7: Disease – Egypt.

Justification of Rating

Culture of the species under assessment predominantly takes place in brackish ponds in Egypt but in ocean cages in the EU and Turkey. Due to the differences that these production systems present, the potential risk of local pathogens and parasites becoming amplified on fish farms and then retransmitted to local wild species that share the same water body is somewhat different for either farming scenario. For this reason, two separate reviews have been prepared for this Criterion.

Disease: Risk-based assessment - EU & Turkey

As disease data quality and availability is moderate (i.e. Criterion 1 scored 5 out of 10 for the disease category), the Seafood Watch Risk-based assessment was utilized for review of the sector in the EU and Turkey.

Since there is no impermeable barrier, a characteristic of open net-pen culture systems is their vulnerability to disease transmission between cages and also between wild and farmed stocks – although evidence of such pathogen exchanges has rarely been documented (ICES 2012). Water currents are one of the main mobilizers of aquatic pathogens, together with other potential on-farm vectors such as infected juveniles, feed and/or equipment. Large-scale fish losses due to bacterial or viral diseases are reportedly not a common occurrence in contemporary Mediterranean aquaculture due to advances that have been made in the development of disease prevention and treatment tools (FFE 2018). The ongoing development of effective vaccines has also resulted in a diminished reliance on antibiotics, as described in Criterion 4 (SEP 2015). Other preventative measures which are currently in development are immunostimulants and probiotics, and researchers are developing tools to tackle parasite challenges (FFE 2018).

<u>Diseases in the EU and Turkey: An overview of the current status</u>

Since 2012, the European Union Reference Laboratory for Fish Diseases (EURL) has conducted an annual survey to track the development and impact of fish diseases in aquaculture in the Mediterranean region and, once collated, this data is presented in a report. A review of the last three annual reports (EURL 2017, EURL 2016, EURL 2015) do not indicate any significant changes in the health status of the seabream, seabass and meagre sector from year to year, although no categorization of health status (e.g. "good" or "poor") is indicated. A recent farm-level survey of seabass and seabream farms across the Mediterranean region, inclusive of Turkey, identified that the median survival percentage experienced during on-growing was 85% for seabass and 80% for seabream, and that the median percentage of disease-related mortality was 10% for both species (Cidad et al. 2018). These data, which were compiled by the Horizon 2020 MedAID project, are shown in Figure 23.

STATISTICAL	% Survival end of period		% mortality by pathology		% mortality by other causes	
	Seabass	Seabream	Seabass	Seabream	Seabass	Seabream
n	67	58	55	44	55	44
Mean	84.18	80.76	10.32	9.63	6.61	10.53
SD	10.11	7.66	9.20	6.19	5.42	7.08
Median*	85.00	80.00	10.00	10.00	5.00	10.00
Q3-Q1	15.00	4.50	13.00	9.74	5.00	11.52
Mode	80.00	80.00	15.00	10.00	5.00	5.00
Minimum	64.00	58.43	0.00	0.00	0.00	1.00
Maximum	100.00	99.00	36.00	18.00	24.62	27.21

**Median is the best parameter describing a mid-value of the data due to skewness*

Figure 23: MedAID Deliverable 1.2 data showing the average survival (%) at the end of the on-growing period, and mortalities (%) due to diseases and other causes (%), for seabass and seabream. Note that 'n' is the number of cohorts put to sea. Data sourced from Horizon 2020 project MedAID Fish Farm Survey, which analyzed data from 50 production units across the Mediterranean region between 2015 and 2017 (Cidad et al. 2018)

Of note, communications with various European producers also indicate a similar average survival percentage for seabass (+90%) (pers. comm. Philippe Sourd, DVM PhD, November 2019), (and 81%), seabream (82%) and meagre (80%) (pers. comm. John A. Theodorou, PhD., December 2019), whereas a recent FAO report notes an average survival of 98% for both seabass and seabream in Turkey, post vaccination at 5-10g and 15-20g, respectively (GLOBEFISH 2017). While vaccine research and development is an ongoing endeavor, a recent paper on this topic notes that most commercial vaccines currently in use by the sector protect stocks against a range of Gram-negative bacteria, including Streptococcus spp., *Tenacibaculum maritimum*, *Listonella anguillarum*, and *Photobacterium damselae* (Miccoli et al. 2019).

In addition to conducting the aforementioned annual survey of fish diseases across the Mediterranean region, the EURL also host an open access database to promote the global sharing of information concerning fish pathogens[97]. In a recent EURL workshop, the consensus of farmers across the entire Mediterranean sector was that the disease of most concern was viral nervous necrosis (VNN), also known as viral encephalopathy and retinopathy (VER) (Vendramin et al. 2016). In fact, for some time VNN has been considered to be the disease of greatest concern impacting both aquaculture (GFCM 2018b) and wild fish stocks in the Mediterranean and Aegean, and detection amongst wild populations is said to be steadily increasing (pers. comm. Anna Toffan, DVM PhD, September 2019; MedAID 2018). It should be noted, however, that the impact of VNN on aquaculture is evidently much less in some regions than in others; while it is noted as an "*important disease*" in Cyprus and Greece (GFCM 2018b), it is reportedly not an industry concern in Turkey and prevalence in France, Croatia and Spain is also very low, the latter averaging losses of <0.5 - 1% (pers. comm. Philippe Sourd, DVM PhD, November 2019). The second and third most problematic diseases identified in recent years are parasitic and bacterial infections (Vendramin et al. 2016). The majority of viruses and bacteria are transmitted horizontally (i.e. via contact with infected fish and virus-contaminated water and/or feed) but vertical transmission (i.e. from broodstock to offspring via eggs or sperm) also occurs (Arechavala-Lopez et al. 2017a, Arechavala-Lopez et al. 2013). Industry mortality data for the different disease categories impacting farmed seabass and seabream are shown in Figure 24.

Disease/Pathogen	Percentage mortality range (minimum and maximum) and median (in brackets)		
	SEABASS		
	Growing	**Hatchery**	**Pre-growing**
Vibriosis	0.003 - 4 (0.8)	0.2 - 10 (0.4)	0.2 - 5 (1)
Tenacibaculosis	0.5 - 3 (1)	2 - 14 (4)	3 - 14
Photobacteriosis	2	0.8	5.5
VER-VNN	0.14 - 7.5 (2)	n/a	n/a
	SEABREAM		
	Growing	**Hatchery**	**Pre-growing**
Sparicotylosis	0.1 - 30 (1)	n/a	n/a
Winter Syndrome	1 -2 (1)	n/a	n/a
Vibriosis	n/a	n/a	1 - 2 (1)

**n/a indicates no records or that data were insufficient to generate the estimate*

Figure 24: MedAID Deliverable 1.2 data showing an overview of the producer-reported mortality data for different disease categories, by species and production phase. Data sourced from Horizon 2020 project MedAID Fish Farm Survey, which analyzed data from 50 production units across the Mediterranean region between 2015 and 2017 (Cidad et al. 2018)

Note that in Figure 24, the disease called 'winter syndrome' was evidently reported by seabream farmers between January and March for the duration of the three-year long survey. This ailment, which is a multifactorial condition of unknown aetiology, is not associated with any specific pathogen. The term 'winter syndrome', or 'winter disease', has arisen due to the

[97] http://www.fishpathogens.eu

fact that this condition particularly impacts seabream during prolonged cold weather periods, when temperatures drop below 13°C (Mateus et al 2017).

<u>Viral diseases</u>
Viral nervous necrosis (VNN), which was first described in the late 1980s, is an infectious disease, which is endemic to many global regions, including Australia, Asia, Europe, North America, Africa, and the South Pacific (Yanong 2016), although no disease outbreaks have been reported in South America (Costa & Thompson 2016). It is documented to affect over 120 species worldwide (Costa & Thompson 2016), including both wild and farmed fish (Vendramin et al. 2013a). VNN is a severe infection which attacks the central nervous system, particularly the brain, spinal cord and retina (Buonocore et al. 2017). The causative agent of VNN is *Betanodavirus,* which belongs to the family *Nodaviridae* and, to date, four discrete genotypes have been identified (Costa & Thompson 2016, Vendramin et al. 2013b). The Aquatic Manual of the World Organisation for Animal Health comments that the life cycle of betanodaviruses is little understood, however, it is likely that this virus originally arose in the wild. Subsequently, the transportation of infected farmed fish from one location to another has undoubtedly facilitated the spread of this virus also (OIE 2018).

As yet, no recommended surveillance procedures or official requirements have been issued concerning monitoring of stocks (pers. comm. Anna Toffan, DVM PhD, September 2019, OIE 2018). VNN is difficult to eradicate and is persistent throughout a broad host range and a wide spectrum of environmental parameters (Buonocore et al. 2017). It is important to distinguish between the prevalence of the nervous necrosis virus (NNV) and the breakout of the disease, viral nervous necrosis (VNN), because only some species are susceptible whereas others are asymptomatic carriers and are considered to be resistant (pers. comm. Ran Berzak, September 2018). Asymptomatic migratory species, therefore, also have the potential to transport this disease over long distances (Cherif & Fatma 2017). NNV can survive for a long time in seawater, capable of infecting susceptible organisms (OIE 2018). Infected marine invertebrates are also a potential vector for the transmission of VNN (Volpe et al. 2017, Panzarin et al. 2012).

In the Mediterranean, one of the species which suffers most acutely from VNN is European seabass (Buonocore et al. 2017, MedAID 2018); as with other susceptible species, seabass are most vulnerable to this virus during larval and juvenile stages, although mortality also occurs in adults (Panzarin et al. 2012). Disease episodes in juveniles can result in 100% mortalities and individuals that survive are generally compromised thereafter in their performance (Costa & Thompson 2016). In contrast to seabass, neither adult seabream nor meagre appear to be susceptible to VNN (pers. comm. Anna Toffan, DVM PhD, September 2019). Until recently, seabream was thought to be resistant to VNN and only an asymptomatic carrier of NNV (Chaves-Pozo et al. 2012, Castric et al. 2011), however, Toffan et al. (2017) report that: "*Unexpectedly, in the last two years an increasing number of marine hatcheries and nurseries in the Mediterranean Sea have experienced severe disease outbreaks and high mortality in sea bream larvae, postlarvae and juveniles caused by betanodavirus infection."* While it is known that meagre can be an asymptomatic carrier of two of the nodavirus genotypes, it is apparently not affected by this disease and, thus far, no viral pathogens have been documented to negatively impact meagre (Soares et al. 2018). One PCR-based analysis that tested apparently healthy wild meagre caught off the Iberian Peninsula's Atlantic coast, found that over 90% of the fish sampled tested positive for NNV (Lopez-Jimena et al. 2010).

There is little information available regarding the bidirectional flow of viral transmissions between wild and farmed fish; however, one project in Italy identified a high degree of genomic similarity in the viruses detected in both wild and farmed populations inhabiting the study area (Vendramin et al. 2013a). As a consequence of these findings, researchers determined that there was a high likelihood that viruses, including betanodaviruses, were freely and continually circulating between wild and farmed species but, since the viral history of wild fish in the region was unknown, further research would be required in order to determine the risks presented by this circulatory transfer of viruses (Vendramin et al. 2013a). Other studies, in other parts of the geographic scope under consideration in this report, also echo similar conclusions, suggesting that there is an on-going and widespread transmission of NNV between farmed and wild populations of fish and that the direction of flow, while challenging to determine, is likely circulatory (Moreno et al. 2014, Panzarin et al. 2012).

Similarly, a recent study in the eastern Mediterranean conducted PCR analysis on wild fish and crustaceans landed at port and sold at local markets: the results revealed an overall prevalence of NNV in 21.49% of the animals tested. Subsequently, the research team conducted an assay on seabream from a newly established offshore farm in the vicinity; this farm only stocked seabream and was also the only aquaculture facility in the region, located far from any other mariculture facilities. Seabream tested prior to stocking, and also seven days post-stocking, all returned negative results, however, 20% of fish analyzed at 120 days post-stocking tested positive for NNV, strongly suggesting that the virus had been introduced to the farm from wild fish. The phylogenetic similarity of the virus detected in both the wild and farmed fish was also ascertained (Berzak et al. 2019). While the flow of pathogens in marine environments is evidently challenging to study, and research into this topic is ongoing, one of the authors of this study commented that these results indicate that spontaneous transmission from wild to farm fish is taking place, and this dynamic is, in turn, affected by the fish species, the fish immune status and the environmental conditions (pers. comm. Dr. Danny Morick, September 2019). The first author further commented that the research team was very surprised to find such a high prevalence of NNV in wild fish species, thus it is difficult to clarify whether aquaculture is the source of this virus or if it causes NNV to be amplified above background levels (pers. comm. Ran Berzak, September 2019). A similar study detected nearly 18% prevalence of VNN in wild fish in southern Italy, including grouper, a species that is highly susceptible to this virus (Vendramin et al. 2013a, pers. comm. Anna Toffan, DVM PhD, September 2019). However, once the virus is inside a farm, the magnitude of viral replication has the potential to increase exponentially and in such cases the farming system can be considered to be an amplifier of the problem (pers. comm. Anna Toffan, DVM PhD, September 2019).

In 2012, a large collaborative project named TargetFish[98] was launched; funded by the European Commission under the 7th Framework Programme (FP7) and coordinated by Wageningen University, the five-year project aimed to prevent the spread of bacterial and viral diseases by developing new aquaculture vaccines and improving existing ones (EU 2015). Numerous immunization studies have taken place in recent years (OIE 2018, Buonocore 2017) which have led to the recent licensing and introduction of two NNV inactivated vaccines in the EU; over 80% of Greek marine fish farm stocks are now reportedly vaccinated against NNV and the use of these vaccines is also increasing in Spain and Italy (pers. comm. Anna Toffan, DVM PhD, November 2019). The TargetFish project concluded in 2017, but work on vaccine development for VNN continues under the MedAID[99] (Mediterranean Aquaculture Integrated Development) project, including trials using third generation vaccines, such as DNA vaccines and recombinant protein vaccines (Barsøe 2018). Recent experiments with selective breeding have also shown potential in improving resistance to VNN in seabass, which primarily suffer from the disease during larval and juvenile stages, although it also manifests in adults (Palaiokostas et al. 2018).

Parasites

A large number of ectoparasites and endoparasites have been documented to affect both wild and farmed seabass and seabream (PerformFISH 2019), however the gill fluke, *Sparicotyle chrysophrii,* is by far the primary parasitic disease constraint impacting the Mediterranean seabream sector (Rigos et al. 2016). Seabream is also affected by enteromyxosis, an enteric disease caused by the microscopic endoparasite, *Enteromyxum leei* - a species belonging to the Myxozoa group of parasites. Enteromyxosis infects the digestive tract and consequentially arrests growth. Parasite infestation often leads to the development of secondary bacterial infections and is also associated with high mortality and stunted growth (Arechavala-Lopez et al. 2017a, Arechavala-Lopez et al. 2013). Meagre is also impacted by Enteromyxosis, plus other parasites in the genera Monogenea, Nematoda, and Dinoflagellate, though mortality is reportedly limited (Soares et al. 2018). The PerformFISH project recently identified, *Lernanthropus kroyeri* and *Ceratothoa oestroides* as the two main parasites impacting the farmed seabass sector at present (PerformFISH 2019).

A great deal of EU-funded research is underway, which aims to increase current understanding of the parasitic diseases impacting the seabass and seabream sector and to develop effective control strategies to combat these. Although experimental trials are underway with multiple substances, including natural compounds such as oregano essential oil and the use of cleaner fish (mainly labrids), there is evidently a very limited number of antiparasitic treatments currently approved for use by seabass, seabream and meagre farmers in the EU. Formalin baths are the only legally permissible antiparasitic agent available to fish farmers in many jurisdictions, including Greece and Spain, thus this control strategy has been the one most widely employed by industry in the treatment of ectoparasites for many years. Reportedly, however, there is a high possibility that this compound will be banned for use in food-fish in

[98] http://targetfish.eu
[99] http://www.medaid-h2020.eu

future. Hydrogen peroxide, which is commonly used as a disinfectant in aquaculture, is also used to combat ectoparasites (PerformFISH 2019).

A European consortium, called ParaFishControl[100], which is funded by the European Union's Horizon 2020 research and innovation programme, aims to improve the understanding of fish-parasite interactions and develop solutions and tools for more effective parasite control in major European aquaculture species. Included in this initiative is the development of anti-parasitic vaccines, but this evidently presents an array of challenges, particularly due to the complicated lifecycle of parasites. Despite on-going developmental efforts, anti-parasitic vaccines are not yet available commercially anywhere in the world (AquacultureDirectory 2018). One of the Work Packages (WP) included in this project focuses specifically on 'Wild farmed fish parasite transfer' and another specifically investigates treatments for parasitic infestation in seabream, thus research into *Sparicotyle chrysophrii* and Enteromyxosis are both included within the scope of the ParaFishControl initiative. This project concludes in March 2020, and data from this initiative will be published at this time. Encouraging results have been obtained with a range of functional feed additives trialed to combat Enteromyxosis (Palenzuela et al. 2017) and dietary supplements of these are now commercially available (pers. comm. Oswaldo Palenzuela, September 2019).

As is the case with viruses, parasite dynamics between wild and farmed fish are poorly understood and challenging to study; however, one investigation recently utilized DNA isolation and polymerase chain reaction (PCR) to investigate such interactions between the monogenean parasite, *Furnestinia echeneis,* and cultured and wild seabream. Researchers concluded that transmission at the farm site was likely occurring and suggested a high potential of transfer from wild populations to farms, though did not comment on transmission from farmed to wild beyond observing "free gene flow" between parasites in farmed and wild fish. (Mladineo et al. 2013).

Bacterial diseases

Globally, bacterial diseases present a significant constraint to the aquaculture industry. The most significant bacterial pathogens impacting the sector under consideration are Vibriosis and Photobacteriosis (formerly Pasteurellosis), which are caused by the gram-negative bacteria *Vibrio anguillarum* and *Photobacterium damselae* subsp. *Piscicida,* respectively. These pathogens, which are endemic throughout the region, impact both farmed and wild fish, although seabass is evidently more severely affected than seabream (Spinos et al. 2017) or meagre (Soares et al. 2018). In recent years, vaccines have become a standard part of husbandry protocol for seabass and seabream farms in the EU and Turkey to mitigate against bacterial pathogens, though antibiotic use still occurs, as noted in Criterion 4 – Chemicals (FFE 2018).

Commercially available bivalent vaccines, which attenuate both *Vibrio anguillarum* and *Photobacterium damselae subsp. Piscicida*, are reportedly used routinely by the seabass

[100] http://www.parafishcontrol.eu

and seabream industry to protect stocks (PerformFISH 2019), and these are administered at two distinct lifecycle stages: the first is an immersive vaccine treatment, which takes place when fish are 1-2g, whereas the second is administered when fish are graded at around 15-25g, prior to being stocked in net pens. This latter vaccination is administered via intraperitoneal injection, when fish are large enough to be handled in this way (Spinos et al. 2017). In the field, these vaccines are reportedly more effective against Vibriosis than they are against Photobacteriosis, although a year-long study in Greece, which sought to determine the efficacy of such commercially available bivalent vaccines by running trials with two different commercial formulations, found that significant protection (i.e. an average, cumulative mortality rate of 6%) was afforded against both pathogens by these products (Spinos et al. 2017). The efficacy of bivalent vaccines for these pathogens was similarly demonstrated in another trial, which additionally documented greater survival using a commercial vaccine that contained a non-mineral oil adjuvant, as opposed to one in an aqueous solution: 100% survival versus 92% was documented 49 days post vaccination, after fish were exposed to medium bacterial pressure – versus the control group, which experienced 45% mortality (Bakopoulos et al. 2015).

Vibrio harveyi has also recently been recognized as an emerging disease issue for seabass. While potential *V. harveyi* vaccines are now being explored, this vibrio species is not typically the primary target of vaccines used by the sector, which instead are currently designed to specifically target the main pathogens of concern, i.e. *Vibrio anguillarum* and *Photobacterium damselae subsp. Piscicida* (pers. comm. Joana Firmino, September 2019). Recent laboratory-controlled trials have demonstrated that fish that have been vaccinated against *Vibrio anguillarum* and *Photobacterium damselae subsp. Piscicidae*, which physically appear to be in good health, can still present with significant internal symptoms of *V. harveyi* infection (Firminoa et al. 2019). Vaccines are recognized as one of the most efficient forms of disease prevention, thus a wider range of commercial broad-spectrum vaccines for the seabass, seabream and meagre sector are likely to become available in future (pers. comm. Joana Firmino, September 2019). Mycobacteria infection and tenacibaculosis are other bacterial diseases currently of concern to the seabass and seabream sectors (PerformFISH 2019, Cidad et al. 2018, GFCM 2018b, Vendramin et al. 2016).

Meagre are also affected by Vibriosis as well as Photobacteriosis, but due to the limited production volumes of this species, bespoke vaccines for meagre have reportedly not yet been developed (Soares et al. 2018). Since meagre is a relative newcomer to aquaculture, an understanding of its disease vulnerabilities is only just emerging. Significant meagre mortalities, brought about by mycobacterial infections, were discussed in a Turkish study, by Timur et al. (2015), which noted that seabream in adjacent cages were apparently unaffected – however, to date, this appears to have been the only reported case of mycobacteriosis in meagre (Soares et al. 2018). Currently, systemic granulomatous disease (SGD) is the main overall constraint to the development of meagre culture (pers. comm. Ahmed Elkesh, PhD., September 2018). Nocardia spp. was initially thought to be the aetiological agent of SGD but ongoing research has revealed that the aetiology of this condition is more complex than was first thought and it likely involves a number of factors which are not yet fully understood (IOA 2018). In Spain, where, 100% of meagre stocks are affected with SGD, nutritional parameters have been identified as a contributing factor (Soares et al. 2018), which suggests that formulated diets may need some fine tuning in order to fulfil the nutritional requirements of this species. In general, data concerning diseases of meagre are sparse, and this is perhaps unsurprising since aquaculture knowledge of this species is in its infancy. Various literature sources that discuss the pathology of meagre generally concur that this species is fairly disease-resistant (Kružić et al. 2016, The Fish Site 2009, FAO 2005-2018b), although this may also be accounted for by its short tenure as an aquaculture species.

Requirements for disease reporting in the EU and Turkey

At present, disease reporting is not a routine regulatory requirement in any of the countries where seabass, seabream or meagre are farmed in the Mediterranean basin, including the EU and Turkey. Also of note, pathogens relevant to the species under consideration are not listed as notifiable by OIE[101] (Cidad et al. 2018). In the EU, the lack of specific legal provisions in this regard is evidently because these species are not identified as being susceptible to any of the listed diseases contained in Part II of Annex IV of Council Directive 2006/88/EC102, 103 (pers. comm. Anna Toffan, DVM PhD, November 2019). This Directive, the full name of which is '*Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals*' is the overarching instrument that governs general disease control measures for aquaculture in the EU - although it should be noted that some governance differences are evident at the regional level, such as with importation/exportation and quarantine regulations (Arechavala-Lopez et al. 2013). Similarly, in Turkey no diseases relevant to the species under consideration are notifiable by law, as per '*Circular No. 2007/32 on listed diseases to be registered according to Article 4 of the Animal Health and Sanitation Law*'[104].

EU legislation does stipulate, however, that the aquaculture sector and relevant authorities must report upon significant mortality events, as defined in the aforementioned Council Directive 2006/88/EC, specifically in chapter five, which is entitled '*Notification and minimum measures for control of diseases of aquatic animals*'[105]. Additionally, the EU encourages member states to design and implement their own "*ad hoc*" measures for specific diseases considered relevant for national aquaculture (pers. comm. Anna Toffan, DVM PhD, November 2019). Likewise, in Turkey '*Regulation No. 28190 of 2012 on Aquatic Animal Health and the Protection and Fight Against Aquatic Animal Diseases*'[106] demands that significant mortality events should be reported to the relevant competent authority; interestingly, the first part of this Turkish act notes that this Regulation has been based on two pieces of EU legislation, namely: Council Directive 2006/88/EC and 2008/946/EC.

---

[101] https://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2019/

[102] Part II of Annex IV to Directive 2006/88/EC as amended by Commission Directive 2008/53/EC

[103] https://www.eurl-fish-crustacean.eu/news/nyhed?id=C6CCEFB0-90F0-4FEF-9B1F-57EB89D3645F

[104] https://www.ecolex.org/details/legislation/circular-no-200732-on-listed-diseases-to-be-registered-according-to-article-4-of-animal-health-and-sanitation-law-lex-faoc109356/?

[105] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0088&from=EN

[106] https://www.ecolex.org/details/legislation/regulation-on-aquatic-animal-health-and-protection-and-fight-against-aquatic-animal-diseases-lex-faoc109390/?q=aquaculture+disease+turkey

Overview of diseases dynamics and interactions between farmed and wild fish

Pathogens can evolve rapidly as they adapt to environmental change, thus the disease challenges faced by marine species, both wild and farmed, change over time. Soares et al. (2018) comment that, while *"old pathogens"* – such as viral encephalitis and lymphocystis, and bacterial diseases such as pasteurellosis and vibrio, or parasitic ailments such as *Amyloodinium ocellatum* - are still evident, new diseases continue to emerge.

A report on *'Pathology and Diseases of Marine Organisms*', produced by the International Council for the Exploration of the Sea (ICES), notes that both policy makers and farmers have greatly increased their awareness of the potential for pathogens to be transmitted between wild and farmed stocks in recent years. This has resulted in greater efforts toward monitoring the health of farmed fish and understanding the disease issues they face, such that management measures to mitigate against the spread of disease are now a routine part of husbandry practices. This report also comments that, since a similar level of scrutiny and research has not been applied to wild stocks, an imbalance in research and monitoring can sometimes give rise to the mistaken perception that farmed stocks are disease-prone and that wild stocks are more *"pristine"* in comparison. (ICES 2012).

However, as noted above, disease reporting is not a routine regulatory requirement in either the EU or Turkey and specific monitoring requirements are not well-defined by regulatory bodies across the region. This situation means that it is challenging to ascertain the extent to which disease-limiting biosecurity management measures are implemented across the sector, such as the use of certified disease-free fry and the disinfection of equipment, etc. It is interesting to note, in this regard, that the ongoing EU-funded MedAID project incorporates a biosecurity survey of Mediterranean marine fish farms in WP4 Task 4.1. The goal of this endeavor is to evaluate the risks that pathogens present to the sector and to determine the mitigating management measures employed by farms. Once concluded, this risk analysis is intended to facilitate the provision of regional recommendations based on these findings (pers. comm. Anna Toffan, DVM PhD, November 2019, Cidad et al. 2018). This may also help facilitate greater public-facing transparency with regards to the industry's application of biosecurity best management practices, which at present is challenging to determine or quantify – even though many farms may indeed have such measures in place. Of note, personal communications with Greece's Hellenic Aquaculture Producers Organization[107] (HAPO), which represents 90% of the Greek aquaculture industry, confirms that best management practices, such as year-class separation, species rotation, and site fallowing are routinely implemented by the sector (pers. comm. John A. Theodorou, PhD, December 2019), despite there being no official requirement for such measures to be documented and reported upon.

Conclusions and final score: EU & Turkey

To conclude, while there is relatively sparse documentation of disease transmission occurring between wild and farmed fish within the EU and Turkey, it appears likely that a dynamic and perpetual circulation of pathogens and parasites is ongoing, since net pen systems are open to

[107] https://fishfromgreece.com/about/

their surroundings and consistently exchanging water with the surrounding environment. A review of literature on the sector indicates that both policy makers and farmers have greatly increased their awareness of disease issues in recent years, although it is hard to quantify the degree to which biosecurity measures (e.g. disinfection of equipment, use of certified disease-free fry, etc.) intended to stem the transmission of disease are implemented. Vaccination, which is recognized as one of the most efficient forms of disease prevention, is now a routine procedure on the majority of farms; this has undoubtedly done much to mitigate the spread of pathogens. However, although significant mortality events are notifiable by law in either jurisdiction, it does not appear that routine monitoring and reporting of disease incidence and/or mortality is legally required by any regulatory body. Recent survey data indicates that the average disease-related mortality rate for seabass and seabream farmed in the EU and Turkey is around 10% of the total fish stocked post hatchery; the total mortality rate is 15 – 20%, indicating that 50% of mortalities are attributable to disease. It is clear that some disease-related mortalities occur on farms, and though there are a number of biosecurity protocols in place, their implementation varies. Given the openness of net pens, the production system is open to the introduction and discharge of pathogens and parasites. This results in a moderate score of 4 out of 10 for Criterion 7: Disease - EU & Turkey.

Disease: Risk-based assessment - Egypt

As disease data quality and availability is moderate (i.e. Criterion 1 scored 5 out of 10 for the disease category), the Seafood Watch Risk-based Assessment was utilized to review the sector in Egypt.

The European Union Reference Laboratory for Fish Diseases (EURL), which conducts an annual survey to track the development and impact of fish diseases on mariculture in the Mediterranean region, includes the southern Mediterranean region, incorporating Egypt, within its scope. As with all other areas covered in the survey, VNN was identified as the number one problem experienced in the southern Mediterranean. Parasites were identified as the second and third most pressing disease issues and the fourth and fifth pathogens of most concern to the region were bacterial infections. The survey included the following remarks concerning each of the most prevalent diseases in the region (Vendramin et al. 2016):

1. *VER/VNN is the disease considered to have the highest impact on production and economy in the southern Mediterranean, including Tunisia and Israel. Therefore the production shifted towards production of sea bream, which is less susceptible to VNN than seabass.*
2. *Gill flukes represent a major sanitary issue in the whole northern African production region including Tunisia, Morocco and Algeria.*
3. *Enteromyxosis in bream is considered to be the third most important problem due to the reduction of growth in affected fish in northern African countries.*
4. *Photobacteriosis still remains a major problem in the whole area, both bass and bream are affected, and the efficacy of the vaccine does not last for a long period. **

5. *Mycobacteria infection is quite important due to its impact in closed recirculating facilities, based on the zoonotic features of this pathogen and on the difficulty in treating the infection properly.*

   * In light of this statement, it is relevant to note that researchers have recently documented improvements in this efficacy of these vaccines, as is explored in more detail above, in the EU section of this Criterion above (Spinos et al. 2017, Bakapoulos et al. 2015).

It should be noted, however, that while the above incorporates data from the geographical range that includes the Mediterranean coast of Egypt, it does not only pertain to Egypt. Contemporary data on disease impacts in Egyptian aquaculture are sparse and only a few studies on this topic were identified. Of note, a large-scale, EU-funded survey conducted by the African Union – Inter-African Bureau for Animal Resources (AUIBAR) in 2016, which aimed to "*Elucidate the range and prevalence of aquatic animal diseases in North Africa*" does not list VNN as a disease of concern in Egypt. In fact, the only disease of relevance to this assessment that is highlighted in the AUIBAR survey is a report from one seabream farm where mortalities of 30% were experienced due to the parasitic gill fluke, *Sparicotyle chrysophrii.* However, authors of the AUIBAR survey also report that it proved challenging to obtain satisfactory questionnaire responses from the Egyptian sector, with only one respondent providing relevant epidemiology details (AU-IBAR 2016).

Types of parasites	Sea bass		Sea bream	
	Winter	Summer	Winter	Summer
Isopoda spp.	_	30	_	92
Dactylogyrus spp.	38	__	43	__
Gyrodactylus spp.	__	69	__	87
Cryptocaryon irritans	10	__	24	_
Trichodina spp.	__	32	__	26
Chilodonella spp.	12	__	23	__
Ichthyobod-necatrix	_	29	__	24
Total	60	160	90	224

Figure 25: The prevalence and seasonality of parasites isolated in seabass and seabream cultured in Maryut lake valley region in Borg El-Arab, Alexandria Governorate, Egypt (Khalil et al. 2014) (note that these are not prevalence percentages but the number of infected fish identified with each parasite)

One study was located that sought to isolate and identify the different parasites impacting production of seabass and seabream in Alexandria Governorate (Khalil et al. 2014). As can be seen in Figure 25, there is a seasonality to parasitic infestation pressure. Seabream was noted to be more heavily infested with parasites than seabass, particularly during summer.

In neighboring Damietta Governorate, another recent study investigating parasitic infestation of cultured seabass and seabream in Egypt identified *Dactylogyrus sp*., *Gyrodactylus sp*. and *Cryptocaryon irritans* as the most prevalent species infecting fish. During the summer months of the study period, *Dactylogyrus sp*. was found to affect 70% of seabass and 87% of seabream, whereas in the winter, *C. irritans* was detected in 57 % of seabass and 97% of seabream (Khalil et al. 2018).

Also in Damietta Governorate, a year-long study on parasitic infestation of cultured seabream was conducted. As can be noted in Figure 26, an average of 32% of the fish sampled during the study period presented with some degree of infestation, and parasite loading was observed to be heaviest during the summer months. Interestingly, the authors note that "*With the exception of Encotyllabe spari, the detected parasites are new records for the monogenean fauna of Egypt (new geographical record) and also Sea bream (Sparus aurata) is a new host record for the monogenean Choriocotyle chrysophri,"* (Mahmoud et al. 2014).

Season	No of fish		No. of infested fish with			
	Examined	Infested (%)	*Encotyllabe spari*	*Furnestinia echeneis*	*Sparicotyle chrysophrii*	*Choriocotyle chrysophrii*
Winter	100	19	4	10	5	2
Spring	100	33	9	16	8	4
Summer	100	48	20	34	13	11
Autumn	100	28	9	15	7	5
Total (%)	400	128 (32)	42 (10.50)	75 (18.75)	33 (8.25)	22.0 (5.5)

Figure 15: Prevalence and seasonal dynamics of the detected monogenean species in cultured seabream (*Sparus aurata*) from Ezbet Elborg, Damietta Province, Egypt (Mahmoud et al. 2014)

In response to high levels of mortalities reported by farmers culturing seabass, Moustafa et al. (2014) conducted a number of bacteriological and histopathological studies to determine the cause. The results of these studies are shown in Figure 27. The authors concluded that bacterial infections were linked with poor water quality (Moustafa et al., 2014). The effect of fluctuating water quality on immune-suppression is also highlighted by other researchers (Abdel-Aziz et al. 2013).

Bacterial strains	Winter outbreak		Summer outbreak		Total	
	No. of isolates	Seasonal incidence	No. of isolates	Seasonal incidence	No. of isolates	Total incidence
V. alginolyticus	8	12.9	12	19.35	20	32.25
V. vulnificus	0	0	7	11.29	7	11.29
P. fluorescens	13	20.96	2	3.22	15	24.19
T. maritimum	3	4.83	8	12.9	11	17.74
S. agalactiae	0	0	9	14.51	9	14.51
The total number of isolates	24	38.7	38	61.29	62	100

Figure 16: Incidences of bacterial infection in cultured seabass growing in floating net-cages and earthen ponds in Northern Egypt during 2012 (Moustafa et al. 2014)

Another study was identified which examined the relationship between bacterial infection and the presence of heavy metals in cultured meagre in the Alexandria Governorate. The study tested for 22 different bacterial pathogens in cultured meagre; the most prevalent was *V. alginolyticus* (10% prevalence) followed by *Tenacibaculum maritimum* and *V. ordalii* (both 8% prevalence). A similar study, which assessed bacterial infections of cultured seabass and seabream in the same area, found that Vibriosis, followed by Pseudomoniasis, then Tenacibaculosis were the most prevalent bacterial diseases affecting these species (Saad & Atallah 2014). It is interesting to note that one study which focused on wild marine fish in Egypt also concluded that bacterial pathogens are the most significant agent affecting wild fish (Moustafa et al. 2010).

Secondary fungal infections have also been reported in farmed seabream, seabass and meagre and remedied by increasing the salinity of the culture water (El-Atta 2013). In Alexandria Governorate, Abdel-Latif et al. (2015) conducted a year-long study investigating mycotic infections in seabream and identified that the most prevalent fungi species were *Aspergillus*, *Cladosporium*, and *Fusarium* and that the presence of these were elevated by heavy metals and poor water quality.

It is notable that despite the evidently significant impact of VNN on European mariculture, no discussion of this virus was noted in literature pertaining to the Egyptian sector. A report prepared by WorldFish, entitled '*A Review of Fish Diseases in the Egyptian Aquaculture Sector*', comments that "*There is currently little information about viruses infecting fish populations in Egypt*," (Aly 2013). No specific references to marine species are made in this report, which is perhaps unsurprising given the dominance of tilapia production in the country. However, VNN impacts both saltwater and freshwater species (OIE 2018), so it is interesting to note the absence of this virus amongst the numerous infectious and non-infectious diseases that are listed – particularly due to the severity of this disease in other parts of the Mediterranean. Another report, which provides a developmental overview of the Egyptian aquaculture value chain notes that: "*Egypt does not have a system for coherent animal health control systems for the aquaculture sector thereby exposing the sector to potential disease risks*," (Mur 2014), which indicates that there is a lack of capacity in this area of aquaculture management. This view is shared by Aly (2013), who comments on the sector's "*Lack of legislation and poor public service veterinary services*". Likewise, an overview of the sector prepared by FAO notes that: "*Regulatory provisions for quality, biosecurity, traceability and safety of farms and farmed fish products and fish feed inputs and veterinary medicines are weak or inactive*," (FAO 2017b).

In conclusion, while there is not a great deal of literature detailing diseases impacting mariculture in Egypt, it is evident that numerous bacterial and parasitic diseases do hamper the sector and that these result in mortalities. Data on viruses is notably absent. No studies were identified that address the potential of on-farm diseases to become amplified and retransmitted to local wild species sharing the same water body. In situations where there is a known pathogen/parasite transfer risk - as there clearly is in Egypt's open, flow through pond systems - and fish health and biosecurity regulations or management measures do not exist, or are in place but implementation and enforcement is unknown, the Seafood Watch Standard considers the pathogen and parasite interaction risk to be moderate-high. As such, the score for Criterion 7: Disease – Egypt is 2 out of 10.

Conclusions and final score: Egypt

There is not a great deal of literature detailing diseases impacting mariculture in Egypt, yet it is evident that numerous bacterial and parasitic diseases hamper the sector and cause mortalities in these flow through pond systems, which are open to the environment. Data on viruses is notably absent and no studies were identified that address the potential of on-farm diseases to become amplified and retransmitted to local wild species sharing the same water body. In light of a deficiency of data to robustly inform this Criterion, and because disease control systems, regulations, and management measures largely do not exist - and where they do, their implementation and enforcement is unknown and/or ineffective - the potential ecological risk of the sector is assessed to be moderately high which results in a score of 2 out of 10 for Criterion 7: Disease – Egypt.

Criterion 8X: Source of Stock – independence from wild fisheries

Impact, unit of sustainability and principle

- Impact: the removal of fish from wild populations for on-growing to harvest size in farms
- Sustainability unit: wild fish populations
- Principle: using eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture.

This is an "exceptional" criterion that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score. A score of zero means there is no impact.

Criterion 8X Summary: EU & Turkey

Source of stock parameters	Score	
C8 Independence from unsustainable wild fisheries (0-10)	0	
Critical?	NO	GREEN

Criterion 8X Summary: Egypt

Source of stock parameters	Score	
C8 Independence from unsustainable wild fisheries (0-10)	-8	
Critical?	NO	RED

Brief Summary

As with many of the criteria considered in this report, there is a significant difference between the source of juveniles stocked by farmers in Egypt compared to those used in the EU and Turkey. For this reason, these sectors have been assessed independently for this Criterion. Traditionally, seabass, seabream and meagre were captured from the wild and subsequently grown out in captivity throughout their natural range. On-growing typically took place in managed lagoons and coastal ponds; initially, these water bodies were stocked by naturally migrating fry and later on they were stocked through the efforts of targeted wild-capture. In Europe, a decline in the abundance of wild juveniles was observed in the 1960s and subsequent legislation, plus investment in research and hatcheries, brought about an almost complete cessation of wild fry use by farmers. Nowadays, hatcheries in the EU and Turkey produce ample fingerlings for the sector and this is primarily accomplished using domesticated broodstock. A similar downward trend in the abundance of wild marine fry has recently been observed in Egypt but, as yet, only limited quantities of hatchery-reared juveniles are available, and the industry is heavily reliant on wild-sourced fingerlings. These divergent sources of stock result in profoundly contrasting scores for either region: the final numerical score for Criterion 8X: Source of Stock – EU & Turkey is a deduction of 0 out of -10, which indicates that there is no environmental impact, whereas Egypt, due to its dependence on wild fry (>80% reliance on wild-stocks), has a deduction of -8 out of -10 for Criterion 8X: Source of Stock - Egypt.

Justification of Rating

An Historical Perspective

Traditionally, both seabass and seabream were trapped in brackish ponds, salt marshes and coastal lagoons across their native range and on-grown, feeding on naturally occurring biota, until they were harvested. In Egypt, such systems are known as '*hosha*', in Spain they are called '*esteros*', and in northern Italy the method is termed '*valliculture*'. This method of culture was practiced until the 1960s, when declines in abundance of wild juveniles and increasing wild-collection efforts prompted a number of local authorities to pass legislation limiting or banning wild collection; as a result, researchers began exploring domestication of these species.

Nowadays, a few traditional farms still exist, raising seabass in coastal ponds and lagoons, and some of these extensive aquaculture systems continue to use wild-caught fry, although the quantities are small (pers. comm. Donatella Crosetti, PhD., October 2019). Modern, intensive cage farms in the EU and Turkey, however, are 100% reliant on hatchery raised fry (Seafish 2019, EC 2018b, Seafish 2015).

Modern hatchery production in the EU and Turkey

Modern hatchery production of seabass and seabream in the EU and Turkey has minimal reliance on wild broodstock: the European Commission note that "*The reproduction of seabass is controlled from start to finish in hatcheries, using broodstock selected in fish farms*," (EC 2018b) and for seabream, "*Healthy broodstock used to be selected in their natural setting. Nowadays, seabream eggs are most often obtained from fish reared in fish farms*," (EC 2018c). Although the majority of seabream broodstock are from domesticated stocks, Crosetti et al. (2014) comment that wild broodstock are sometimes included along with F1's in breeding programs, however, these additions are infrequent and are estimated to constitute <10% of the total (pers. comm. Donatella Crosetti, PhD., April 2019; pers. comm. John A. Theodorou, PhD., April 2019). Male seabream broodstock present a particular challenge to hatcheries: since seabream is a protandrous hermaphrodite, individuals are male until they are around 30cm long (about two years old) after which they turn into females, thus hatcheries must replenish male broodstock of this species according to this bisexual cycle (Sola et al. 2006). Hatchery production of meagre is still a fairly recent development, however good reproductive success has evidently also been achieved with F1 meagre broodstock (Soares et al. 2015). With regards to the industry's occasional use of wild broodstock, the IUCN Red List of Threatened Species lists the status of European seabass, gilthead seabream and meagre as being of 'Least Concern' (Freyhof & Kottelat 2008, Russell et al. 2014, Pollard et al. 2015).

In conclusion, it is evident that the EU and Turkish sector can maintain the reproductive cycle of target species within a hatchery setting by using domesticated broodstock and with minimal wild inputs. As a result, the final score for Criterion 8X – Source of Stock for EU and Turkey is 0 out of -10.

Source of stock: Egypt

While modern-day commercial production of seabass, seabream and meagre in the EU and Turkey is reliant on hatchery-raised juveniles, production of these species in Egypt is still primarily dependent on wild-caught fry (AU-IBAR 2016).

Egyptian hatcheries predominantly produce freshwater species such as tilapia, catfish and carp (Soliman 2017). Marine hatcheries are few in number and, due to their technological constraints, the production of seabream and seabass is minimal at present (Soliman 2017b). As shown in Figure 28, marine hatchery production comprised just 2% of total Egyptian hatchery production in 2014, which amounted to 13.1 million juveniles; this quantity was primarily comprised of mullet, seabream and seabass (note that mullet is by far the main marine species produced – accounting for almost three-quarters of aggregated marine tonnage (FAO 2017a). To put this in context, in the same year, 72 million marine fry were collected from the wild (FAO 2017b). No mention of domestic hatchery production of meagre in Egypt was identified in literature.

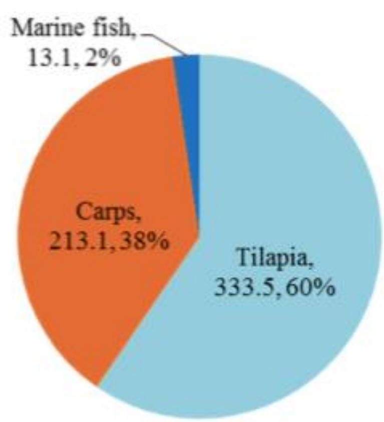


Figure 28: Hatchery-produced juveniles (in millions) in the Arab Republic of Egypt in 2014 – data from GAFRD (FAO 2017b)

A recent FAO (2017b) regional review of aquaculture in the Near East and North Africa (NENA) notes that the collection of wild marine fry for aquaculture is a common occurrence in this region and that the practice is particularly prevalent in Egypt; the main species impacted by these activities are mullet, seabream, seabass, eel and meagre. The report notes that continuation of this activity will likely lead to major declines in the abundance of these species in the wild. Decision No. 592/2012 regulates the wild collection of juvenile marine fish for the purpose of stocking aquaculture facilities (FAO 2017b) and Law No. 124/1983 specifies that wild collection of fry is illegal unless permitted by GAFRD. GAFRD permits are issued on the condition that the fry must only be sold to GAFRD. This practice, however, has reportedly resulted in an unregulated black-market supply chain of wild-caught juveniles, with undocumented quantities being collected (Cataudella et al. 2015, Rothuis et al. 2013). This situation means that it is challenging to determine what percentage of fry is hatchery-raised versus wild-caught. The following summarizes the data that is available and extrapolates a best estimate of the source of juveniles for the three species under consideration.

According to statistics from GAFRD, the combined output of private and government hatcheries in 2012 was 2.25 million seabass and 1.796 million seabream (a combined total of just over 4 million), as is shown in Figure 29 (Hebisha & Fathi 2014).

Species	Governmental hatcheries					Private hatcheries				
	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
Sea bream	0.25	0.25	0.25	0.25	0.25	2.00	0.49	2.00	2.00	2.000
Seabass	0.26	0.25	0.26		0.196	1.60	3.16	1.60	1.60	1.600

Figure 29: Quantities of European seabass and gilthead seabream produced by government and private hatcheries (in millions) between 2008–2012 – data and figure reproduced from GAFRD (Hebisha & Fathi 2014)

As noted above, hatchery production of meagre was not identified in any statistics concerning Egyptian hatchery production, though a survey on meagre farming in the western region of Port Said noted that 100% of stocked fry were wild-sourced (Abdelhamid et al. 2013). Meagre production is also absent in GAFRD's most recent Fish Statistics Year Book (GAFRD 2018b), which records 2016 hatchery production of seabream juveniles as 8,538,000, hatchery production of seabass as 5,686,000, and legal wild collection of both species is recorded as 900,000.

A recent presentation on the marine sector (El-Gamal 2018) concurs that hatchery production of the species under consideration is minimal and that there is a downward trend in the quantities of marine fry obtained through wild collection as follows: 1990 – 148 million; 2012 – 73 million; 2014 – 72 million; 2015 – 95 million; and in 2016 – 51 million. El-Gamal (2018) also includes marine hatchery production figures for 2014 (13 million), 2015 (30 million) and 2016 (45 million) and states that the marine fry produced are seabass, seabream and shrimp – although one million mullet fry were also produced in 2015. While it is unclear which species are included in the wild capture efforts, it is evident that the main species targeted by collectors is mullet, which El-Gamal estimates accounts for around 98% of the total. Other authors, commenting on previous years, suggest that mullet comprises 78% of wild caught fry (Goulding & Kamel 2013, Cataudella et al. 2015). Although mullet fry is the main species targeted and caught, seabass, seabream and meagre are also included in the mix – inevitably along with a bycatch of non-target species also (Troell et al. 2017).

In their 2013 review of the Egyptian aquaculture sector, WorldFish extrapolated the likely amount of illegal marine fry used in the production of cultured mullet, seabream and seabass by using known hatchery and wild collection fry quantities and comparing them with the reported harvest quantities of these species. The authors also factored in an estimated survival rate into these calculations. These data are shown in Tables 12 and 13.

Table 12: Sources and numbers of marine fry used by the Egyptian aquaculture sector in 2011 (reproduced from Goulding & Kamel 2013)

Source	No. Of Units	%
GAFRD fry centers	62,528,000	4.1
Hatchery	15,800,000	1.0
Illegal catch	1,437,477,776	94.8
Totals	1,515,805,776	100

Table 13: Estimated demand for marine fry used by the Egyptian aquaculture sector in 2011, calculated using GAFRD statistics and industry data (reproduced from Goulding & Kamel 2013)

Group	Production (ton)	% of Production	No. Of Units	Survival %	Original No. required
Mullets	114,001	78	409,006,587	30	1,363,355,290
Seabass	17,714	12	63,553,326	75	84,737,768
Seabream	14,155	10	50,784,539	75	67,712,719
Totals	145,870	100	523,344,452		1,515,805,776

Applying the same logic as the 2013 WorldFish report, Tables 14 and 15 make similar calculations using El-Gamal's more recent hatchery production and wild-capture statistics. This analysis indicates that hatchery production accounted for 8% of production in 2014, 17% in 2015 and 15% in 2016. These calculations assume the following: 2% of wild-captured fry are seabass, seabream and meagre (i.e. 98% are mullet); fish are harvested at 300g; the survival rate is 75%, as per Table 13 – although survival of wild captured fry, particularly when unregulated, is likely much lower than this (EI 2012); and also, for ease of calculation, an assumption is made that all marine hatchery production is comprised of the species under consideration (although a small amount is likely shrimp and mullet). Table 14 provides an example of these detailed calculations for 2014 and a summary of the extrapolated values for 2014 – 2016, which were obtained using this method, are shown in Table 15.

Table 14: Calculation of the source of fry inputs basis FAO (2018a) production figures and available industry information (El-Gamal 2018)

Source of Fry 2014		Total Fry Inputs	Total MT	%
GAFRD wild-fry	72,000,000			
2% target species * (seabass, seabream, meagre) =	1,440,000	1,440,000		1%
@ 75% survival = **	1,080,000			
Yield in MT =	324		324 MT	
Hatchery fry **	13,000,000	13,000,000		8%
@ 75% survival = **	9,750,000			
Yield in MT =	2,925		2,925 MT	
GAFRD & Hatchery yield in MT =	3,249			
Actual Production in MT	38,018			
Shortfall in MT	34,769		34,769 MT	
Illegal wild-fry needed	115,896,667			91%
@ 75% survival = **	154,528,889	154,528,889		
TOTAL		168,968,889	38,018 MT	100%

* % target species estimate, and hatchery production data taken from El-Gamal 2018
** % survival estimate taken from Goulding & Kamel 2013

Table 15: Estimation of the various sources of juveniles used to produce the quantities of cultured seabass, seabream and meagre reported to FAO (2018a) during 2014-2016 (El-Gamal 2018)

Fry Source	2014	%	2015	%	2016	%
GAFRD Wild-fry	1,440,000	1%	1,900,000	1 %	1,020,000	0.3%
Hatchery fry *	13,000,000	8%	30,000,000	17 %	45,000,000	15%
Illegal wild-fry needed	154,528,889	91%	144,775,556	82%	253,193,333	84%
Total Fry	168,968,889	100%	176,675,556	100%	299,213,333	100%
Total MT produced (all 3 species) **	38,018		39,752		67,323	

* hatchery production data taken from El-Gamal 2018
** data sourced from FishstatJ - FAO 2019

It is evident from the most recent statistics released by GAFRD, which pertain to legal wild-capture of seabream and seabass fry as well as hatchery production of these species in 2016, that hatchery production has increased somewhat, and that legal wild-capture has declined. Production volumes of these species are evidently on the rise; the most recent data from FAO indicates that the 2017 aggregated total production of all three species was 90,954 MT (FAO 2019), demonstrating a significant year-on-year increase in recent times. Of note, the IUCN Red List of Threatened Species includes the status of European seabass, gilthead seabream and meagre under the category of 'Least Concern' (Freyhof & Kottelat 2008, Russell et al. 2014, Pollard et al. 2015). This means that the scoring of this Criterion avoids a 'Critical' rating but, with only around 15% of fry being hatchery-raised, the final score for Criterion 8X – Source of Stock for the Egyptian seabass, seabream and meagre sector is -8 out of -10.

Conclusions and final score

Culture of seabass, seabream and meagre in the EU and Turkey utilizes hatchery-raised juveniles and is virtually self-sufficient. With a negligible (<10%) reliance on wild-stocks for occasional broodstock replenishment, the final numerical score for Criterion 8X: Source of Stock – EU & Turkey is a deduction of 0 out of -10, which indicates that there is no environmental impact with regards to this aspect of production. Due to the Egyptian sector's heavy reliance on wild fry (>80%), the final numerical score for Criterion 8X: Source of Stock – Egypt is a deduction of -8 out of -10.

Criterion 9X: Wildlife and predator mortalities

Impact, unit of sustainability and principle

- Impact: mortality of predators or other wildlife caused or contributed to by farming operations
- Sustainability unit: wildlife or predator populations
- Principle: aquaculture populations pose no substantial risk of deleterious effects to wildlife or predator populations that may interact with farm sites.

This is an “exceptional” criterion that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score. A score of zero means there is no impact.

Criterion 9X Summary: EU & Turkey

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score (0-10)	-2	
Critical?	NO	GREEN

Criterion 9X Summary: Egypt

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score (0-10)	-6	
Critical?	NO	YELLOW

Brief Summary

In conclusion, with regard to the EU and Turkey, although production of the species under consideration inevitably attracts predators, and interactions with wildlife do occur, data from the literature and personal communications indicate that any mortalities that may occur appear limited to exceptional cases. Even in the case of bottlenose dolphins, a Mediterranean subpopulation considered “Vulnerable” by the IUCN, data suggest that despite frequent interactions, entanglements and mortalities are rare. The final numerical score for Criterion 9X – Wildlife and Predator Mortalities is therefore -2 out of -10 for the EU and Turkey.

With regard to Egypt, it is again understood that the production of seabass, seabream, and meagre in ponds attracts wildlife and predators, primarily birds, amphibians, and reptiles. No information could be found with regard to any quantification of these interactions, nor the control methods (or lack thereof) employed by the industry, and information gleaned from literature regarding other pond production sectors in Egypt (tilapia, mullet), where lethal and non-lethal control methods are documented, was used as a proxy. In the absence of additional information, it is assumed that similar lethal and non-lethal control methods are in place in the seabass, seabream, and meagre sectors, and thus it is assumed that wildlife and predator mortalities do occur with unknown impacts to said wildlife species. The final score for Criterion 9X – Wildlife and Predator Mortalities is -6 out of -10 for Egypt.

Justification of Rating

Predator and wildlife mortalities: control measures and their application in the EU and Turkey
As is frequently discussed in this report, two of the primary Directives that govern aquaculture in the EU are the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD). Guidelines issued by the European Commission for the implementation of the WFD and MSFD acknowledge that predator control can be challenging to implement, particularly in instances when depredation is caused by a protected species. The guidelines advise that aquaculture facilities should evaluate the method of control that has the least impact on predators and biodiversity. Dependent on the specific circumstances, a variety of predator control methods can be considered, for example: exclusion methods (such as predator nets or fences); deterrents (such as human presence, acoustic deterrent devices (ADDs) or fake predators); operational/management strategies (such as prompt removal of mortalities and maintaining low stocking densities); site selection strategies (such as, not establishing farms in areas where predators are known to be); or, licensed control measures (such as shooting permits), which must explicitly only be implemented as a last resort (EC 2016).

A study into '*Regulatory and Legal Constraints for European Aquaculture*', which was conducted at the request of the European Parliament's Committee on Fisheries, notes that cormorants, herons and seals, which are protected, often cause considerable economic losses to aquaculture and capture fisheries within the EU, and this situation has been amplified in part by the successful implementation of conservation measures for these species (EU 2009a). In some instances, licenses can be obtained by farmers to legally kill and remove particularly rapacious predators; while no data was identified that indicates such licenses are typically sought by farmers in the seabream, seabass and meagre sector, it is evident that any animals impacted as a result of such deliberate actions must be documented and reported to the European Commission by each member state, as per EU policy. Additionally, it is mandatory to also monitor and report any population level impacts on species caused by accidental acts. The two pieces of EU legislation which dictate this policy, and influence this aspect of aquaculture governance, are the Birds Directive (Directive 2009/147/EC[108]) and the Habitats Directive (Directive 92/43/EEC[109]) (SEP 2015); together, these two acts form the cornerstone of environmental conservation policy across the region. These legal instruments provide a framework of protection for native birds, animals and plants, including those which reside within the Natura 2000 network (EC 2012). Article 12 of the Birds Directive and Article 17 of the Habitats Directive require that member states monitor the status of nature within their jurisdictions and that every six years they must submit a progress report which provides an evaluation of their implementation of these directives. These national reports are available online[110, 111]. Furthermore, Article 9 of the Birds Directive and Article 16 of the Habitats

[108] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0147&from=EN
[109] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31992L0043&from=EN
[110] http://ec.europa.eu/environment/nature/knowledge/rep_habitats/index_en.htm
[111] http://ec.europa.eu/environment/nature/knowledge/rep_birds/index_en.htm

Directive cover member states' reporting obligations for derogations, as applicable to either directive.

The purpose of the Birds Directive (EU 2009c) is to ensure "*The conservation of all species of naturally occurring birds in the wild state in the European territory of the Member States*" and to prohibit the "*Deliberate killing or capture by any method*" of these species. However, Article 9 of this Directive includes provision for derogation in a variety of instances, such as "*To prevent serious damage to crops, livestock, forests, fisheries and water*," if other solutions are unsuccessful. Any derogations must be reported, inclusive of the following details:

(a) the species which are subject to the derogations;
(b) the means, arrangements or methods authorized for capture or killing;
(c) the conditions of risk and the circumstances of time and place under which such derogations may be granted;
(d) the authority empowered to declare that the required conditions obtain and to decide what means, arrangements or methods may be used, within what limits and by whom;
(e) the controls which will be carried out.

Article 9 of the Birds Directive concludes with the statement: "*The Commission shall at all times ensure that the consequences of the derogations referred to*" ... "*are not incompatible with this Directive. It shall take appropriate steps to this end,*" (EU 2009c).

Likewise, the Habitats Directive (EU 1992) allows for derogations in a variety of circumstances, such as in order "*To prevent serious damage, in particular to crops, livestock, forests, fisheries and water and other types of property*". As with the Birds Directive, detailed justification for derogations must be provided to the European Commission.

<u>Literature discussing interactions between predators, wildlife and fish farms in the EU and Turkey</u>
Predators are attracted to fish farm sites not only by the presence of the farmed species themselves but also by the aggregations of wild fish that often occur around cages, enticed there by the potential availability of stray feed pellets plus the shading and substrate that the installation itself provides. Instances where predator interactions are mentioned in literature on the sector include references to bluefish, seabirds and monk seals (Grigorakia & Rigos 2011). Of note, monk seals have been documented to attack fish farm installations in the Turkish Aegean Sea (Díaz López 2017). This species is presently listed as endangered on the IUCN Red List, but with a population trend that is increasing (Karamanlidis & Dendrinos 2015). Monk seals became legally protected in Turkey in 1991 (Kıraç et al. 2004) and while incidental capture of this species is well documented in wild capture fisheries, data on this topic does not mention any such impacts caused by fish farm installations (Karamanlidis et al. 2008). Bottlenose dolphins too are drawn to aquaculture facilities and aggregations of them feeding next to farms in Sardinia, Italy, are especially noted in literature (Díaz López 2017, OSPAR 2009), Pelagics, such as swordfish, have also been observed feeding in the vicinity of cage farms (Arechavala-Lopez et al. 2017a). Guidelines from the European Commission stress the importance of prudent farm-siting to minimize predator interactions (EC 2012). The most recent '*State of World Fisheries*

and Aquaculture' report released by FAO states that the Mediterranean is one of the most unsustainably fished regions of the world (FAO 2018b) and some authors comment that this is a significant driver of predatory attacks on fish farms in the area (Grigorakia & Rigos 2011). A Greek study, described in a publication titled '*Marine open cage aquaculture in the eastern Mediterranean Sea: a new trophic resource for bottlenose dolphins'*, also notes that overfishing has led to increasing numbers of bottlenose dolphins foraging and feeding around cage farms in the region; interestingly, the authors of this report state that in addition to acting as a FAD (fish aggregating device), the nutrients released by marine farms actually increase primary productivity in their vicinity, particularly in oligotrophic regions, and thereby increase the biomass of local fish stocks, which in turn is beneficial to dolphins as it increases the availability of prey (Piroddi et al. 2011).

Evidence of deliberate or accidental mortality impacting affected predatory species, or other wildlife, at the population level was not found in contemporary literature on the sector, although data from the aforementioned study in Sardinia, which took place in the 2000s, and which trialed a number of different predator nets deployed at a seabass and seabream farm, documented the entanglement of 5 dolphins between 2005 and 2008 (Díaz López 2012). The author of this study noted that the anti-predator nets were a new addition to the cage site and that the dolphin's unfamiliarity with this feature may have been a contributing factor in these accidental entanglement incidents (Díaz López 2007, Díaz López & Shirai 2007). Other literature discussing the topic of dolphins and their interactions with fish farms in the region did not mention any instances of dolphin entanglement or mortality that had occurred (BWI 2019, Bonizzoni et al. 2014). Furthermore, an industry expert, with 30 years of extensive regional experience, commented that he was unaware of any dolphin entanglement incidents occurring on the many farms he had frequented over the years (pers. comm. Bertrand Kirsch, August 2019), which suggests such incidences are rare. Of note, the IUCN Red List of Threatened Species ranks the global conservation status of bottlenose dolphins to be of '*Least concern*' (Wells et al. 2019) – however, the Mediterranean subpopulation is currently classified as '*Vulnerable*'[112]. This assessment notes that there has been a rapid reduction in population size over the previous three generations and states that, "*Although the total population size in the Mediterranean remains uncertain, it unquestionably exceeds the threshold level for red listing as Vulnerable*," (Bearzi et al. 2012).

The aforementioned Sardinian study continued to monitor and survey the farm site up until 2013, in order to determine the "*Occurrence, abundance and diversity*" of predators and to "*Evaluate the factors that induced changes in the occurrence of predators*". The author identified that there were four main predators: yellow-legged seagulls were present in 84% of observations, shags in 74%, bottlenose dolphins in 57%, and grey herons were present in 6%. The incidence of both heron and dolphin predation was seen to increase during the progress of the study period, and various patterns were observed, for example, shags were more abundant when sea temperatures were higher, whereas herons tended to migrate elsewhere during warmer periods, and dolphins visited the cage site most frequently at harvest times,

[112] https://www.iucnredlist.org/species/22563/2782611

opportunistically feeding on escapees and discarded fish (Díaz López 2017). The study also states that avian predators were commonly entangled in top netting, though whether these interactions resulted in mortalities is unclear (Díaz López 2017).

Another study, conducted in Spain, considered the potential phylogeographic impacts of Mediterranean aquaculture on the bluefish, a highly migratory species which is also an aggressive piscivorous predator, well-known to predate on seabass and seabream farms. Bluefish present in the Mediterranean region are predominantly comprised of two distinct genetic units; the Western Mediterranean stock, which includes the proximal North-Eastern Atlantic Ocean in its range; and the Eastern Mediterranean stock, which incorporates the Turkish Aegean and the Sea of Marmara. Using molecular tools, the study identified that between 7.14% and 11.9% of bluefish predating on Spanish cages were from the distal, Turkish stock, and concluded that the presence of fish farms, and their proliferation in the Mediterranean basin, is potentially effecting a change in the traditional migratory routes of the bluefish (Miralles et al. 2016).

Predator and wildlife mortalities: control measures and their application in Egypt

No mention of predator control measures were identified in literature on the Egyptian seabream, seabass and meagre sector, although one paper commented that water snakes, aquatic birds, amphibians, and also the invasive freshwater red swamp crayfish, were species which may predate on juvenile fish in earthen ponds (Eissa et al. 2016). Research on the sector did not yield any evidence of mortality of predators or other wildlife caused or contributed to by farming operations. In Egypt, Law No. 4 of 1994 on Environment and also Law No. 102 of 1983 on Natural Protected Areas (FAOLEX 2019b) are the two overarching legal instruments that govern hunting and trapping. The Environment Law, which oversees environmental protection, incorporates international conventions, species protection and hunting management within its reach. Additionally, Law No. 124/1983 specifically regulates hunting activities around inland wetlands, lakes and fish farms; each year an Executive Ministerial Decree is issued by the Environmental Affairs Agency (EEAA) detailing which species it is permissible to hunt or trap and at what time of year it is legal to do so (BLI 2014). However, no further information was identified which provided any further clarity with regards to the volume of take authorized, the environmental impact of authorized take, or the enforcement of these laws. In other Egyptian aquaculture sectors, namely tilapia and mullet, both of which occur in ponds, evidence suggests the use of lethal[113] (e.g. shooting) and nonlethal[114] (bird netting, noise cannons) controls in protecting farmed stock from bird predation, much of which is from protected species[115]. With no additional information otherwise, it is assumed that such control measures are in place in Egyptian seabass, seabream, and meagre farms, and the impacts to the affected species are unknown.

---

113 http://www.tilapia-farming.com/docs/global/egypt/tilapia_farming_egypt.pdf

114 http://www.fao.org/3/af026e/AF026E02.htm

115 https://books.google.com/books?id=69pCDwAAQBAJ&pg=PA448&lpg=PA448&dq=egypt+aquaculture+%22birds%22&source=bl&ots=n7w3B45fVr&sig=ACfU3U1WaRCP9w66hs2Mygg43lxhwWCl2Q&hl=en&sa=X&ved=2ahUKEwicv6KG2_vkAhX7HDQIHSUHDOY4ChDoATACegQIChAB

Conclusions and final score

In conclusion with regard to the EU and Turkey, although production of the species under consideration inevitably attracts predators, and interactions with wildlife do occur, data from the literature and personal communications indicate that any mortalities that may occur appear limited to exceptional cases. Even in the case of bottlenose dolphins, a Mediterranean subpopulation considered "*Vulnerable*" by the IUCN, data suggest that despite frequent interactions, entanglements and mortalities are rare. The final numerical score for Criterion 9X – Wildlife and Predator Mortalities is therefore -2 out of -10 for EU and Turkey.

With regard to Egypt, it is again understood that the production of seabass, seabream, and meagre in ponds attracts wildlife and predators, primarily birds, amphibians, and reptiles. No information could be found with regard to any quantification of these interactions, nor the control methods (or lack thereof) employed by the industry, and information gleaned from literature regarding other pond production sectors in Egypt (tilapia, mullet), where lethal and non-lethal control methods are documented, was used as a proxy. In the absence of additional information, it is assumed that similar lethal and non-lethal control methods are in place in the seabass, seabream, and meagre sectors, and thus it is assumed that wildlife and predator interactions do occur with unknown impacts to said wildlife species. The final score for Criterion 9X – Wildlife and Predator Mortalities is -6 out of -10 for Egypt.

Criterion 10X: Escape of secondary species

Impact, unit of sustainability and principle

- Impact: movement of live animals resulting in introduction of unintended species
- Sustainability unit: wild native populations
- Impact: aquaculture operations by design, management or regulation avoid reliance on the movement of live animals, therefore reducing the risk of introduction of unintended species.

This is an “exceptional” criterion that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score.

Criterion 10X Summary

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	10	
F10Xb Biosecurity of source/destination	10	
C10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**

Brief Summary

The production of seabass, seabream and meagre within the scope of this assessment is not considered to present a risk with regards to the unintentional trans-waterbody shipment of non-native species. Since no deduction is warranted, the assessed score for Criterion 10X – Escape of Secondary Species is 0 out of -10.

Justification of Rating

Factor 10Xa International or trans-waterbody live animal shipments

As is noted in Criterion 8X: Source of Stock, seabass and seabream are both native throughout the geographic range encompassed by this report; this is also predominantly the case for meagre, although it is evidently rare or absent in the more northerly regions under consideration. In Egypt, fry are primarily wild caught and come from adjacent regional waterbodies, thus trans-waterbody movements do not occur within this sector. In the EU and Turkey, where fry for the sector are hatchery produced, trans-boundary shipments do take place, but these boundaries are political, and the waterbodies where on-growing takes place – primarily the Mediterranean but also the North-Eastern Atlantic and the Aegean Sea – are contiguous with one another. A very small amount of production also takes place in the Black Sea, which is linked to the Aegean and the Mediterranean via the Sea of Marmara and the Bosporus. Although the EU and Turkish sector is reliant on fry being transported around the region, these movements are not considered to present a risk of invasive alien species being unintentionally transported alongside the principle farmed species during animal shipments.

Factor 10Xb Biosecurity of source/destination

Since there are no international or trans-waterbody shipments of live animals, there is no risk of transferring organisms between ecologically distinct environments. Further, movements of live aquaculture stock (eggs, broodstock and larvae) within the EU are controlled by Directive 2006/88EC and must be accompanied by a health certificate, as specified in Commission Regulation (EC) No. 1251/2008. These legislative instruments define the biosecurity health requirements that must be adhered to when aquaculture organisms are in transit within the EU (Oidtmann et al. 2011). Thus, the score for Factor 10Xb is 10 out of 10.

Conclusions and final score

Since production of seabream, seabass and meagre within the scope of this assessment does not require shipment of juveniles out with the range of the contiguous waterbodies to which they are native, there is no deduction for this Criterion. The final numerical score for Criterion 10X – Escape of Secondary Species is 0 out of -10.

Overall Recommendations

There are ten overall recommendations as follows:

The overall final score for each recommendation is the average of the individual criterion scores (after the two exceptional scores have been deducted from the total). The overall rating is decided according to the final score, the number of red criteria, and the number of critical scores as follows:

- Best Choice = Final Score ≥6.661 **and** ≤10, and no Red Criteria, **and** no Critical scores
- Good Alternative = Final score ≥3.331 and ≤6.66, **and** no more than one Red Criterion, **and** no Critical scores.
- Red = Final Score ≥0 and ≤3.33, **or** two or more Red Criteria, **or** one or more Critical scores.

Gilthead seabream (*Sparus aurata*) produced in marine net pens in the EU

Criterion	Score	Rank	Critical?
C1 Data	7.50	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	5.21	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**30.97**		
Final score (0-10)	**4.42**		

OVERALL RANKING

Final Score	4.42
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are *exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.*

Summary: Gilthead seabream farmed in the EU

The score for gilthead seabream produced in marine net pens in the EU is 4.42 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

European seabass (*Dicentrarchus labrax*) produced in marine net pens in the EU

Criterion	Score	Rank	Critical?
C1 Data	7.50	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	5.38	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**31.15**		
Final score (0-10)	**4.45**		

OVERALL RANKING

Final Score	4.45
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: European seabass farmed in marine net pens in the EU

The score for European seabass produced in marine net pens in the EU is 4.45 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

Meagre (*Argyrosomus regius*) produced in marine net pens in the EU

Criterion	Score	Rank	Critical?
C1 Data	7.50	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	4.28	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**30.05**		
Final score (0-10)	**4.29**		

OVERALL RANKING

Final Score	4.29
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Meagre farmed in marine net pens in the EU

The score for meagre produced in marine net pens in the EU is 4.29 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

Gilthead seabream (*Sparus aurata*) produced in marine net pens in Turkey

Criterion	Score	Rank	Critical?
C1 Data	7.27	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	1.00	RED	NO
C5 Feed	5.21	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**28.75**		
Final score (0-10)	**4.11**		

OVERALL RANKING

Final Score	4.11
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Gilthead seabream farmed in Turkey

The score for gilthead seabream produced in marine net pens in Turkey is 4.11 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

European seabass (*Dicentrarchus labrax*) produced in marine net pens in Turkey

Criterion	Score	Rank	Critical?
C1 Data	7.27	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	1.00	RED	NO
C5 Feed	5.38	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**28.92**		
Final score (0-10)	**4.13**		

OVERALL RANKING

Final Score	4.13
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: European seabass farmed in marine net pens in Turkey

The score for European seabass produced in marine net pens in Turkey is 4.13 with two Red-ranked criterion for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

Meagre (*Argyrosomus regius*) produced in marine net pens in Turkey

Criterion	Score	Rank	Critical?
C1 Data	7.27	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	1.00	RED	NO
C5 Feed	4.28	YELLOW	NO
C6 Escapes	2.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	0.00	GREEN	
Total	**27.82**		
Final score (0-10)	**3.97**		

OVERALL RANKING

Final Score	3.97
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK

RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Meagre farmed in marine net pens in Turkey

The score for meagre produced in marine net pens in Turkey is 3.97 with two Red-ranked criteria for Chemicals and Escapes. The final ranking is Red and a recommendation of Avoid.

Gilthead seabream (*Sparus aurata*) produced in brackish ponds and lagoons in Egypt

Criterion	Score	Rank	Critical?
C1 Data	3.64	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	2.67	RED	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	5.21	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	2.00	RED	NO
C8X Source	-8.00	RED	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**4.51**		
Final score (0-10)	**0.64**		

OVERALL RANKING

Final Score	0.64
Initial rank	RED
Red criteria	5
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Gilthead seabream farmed in Egypt

The score for gilthead seabream farmed in brackish ponds and lagoons in Egypt is 0.64. With five Red-ranked criteria (Effluent, Habitat, Chemical Use, Disease, Source of Stock), one of which is Critical (Effluent), the final ranking is Red and a recommendation of Avoid.

European seabass (*Dicentrarchus labrax*) produced in brackish ponds and lagoons in Egypt

Criterion	Score	Rank	Critical?
C1 Data	3.64	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	2.67	RED	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	5.38	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	2.00	RED	NO
C8X Source	-8.00	RED	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**4.69**		
Final score (0-10)	**0.67**		

OVERALL RANKING

Final Score	0.67
Initial rank	RED
Red criteria	5
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: European seabass farmed in Egypt

The score for European seabass farmed in brackish ponds and lagoons in Egypt is 0.67. With five Red-ranked criteria (Effluent, Habitat, Chemical Use, Disease, Source of Stock), one of which is Critical (Effluent), the final ranking is Red and a recommendation of Avoid.

Meagre (*Argyrosomus regius*) produced in brackish ponds and lagoons in Egypt using commercial diets

Criterion	Score	Rank	Critical?
C1 Data	3.64	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	2.67	RED	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	4.28	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	2.00	RED	NO
C8X Source	-8.00	RED	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**3.59**		
Final score (0-10)	**0.51**		

OVERALL RANKING

Final Score	0.51
Initial rank	RED
Red criteria	5
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Meagre farmed in Egypt using commercial diets

The score for meagre farmed in brackish ponds and lagoons in Egypt using commercial diets is 0.51. With five Red-ranked criteria (Effluent, Habitat, Chemical Use, Disease, Source of Stock), one of which is Critical (Effluent), the final ranking is Red and a recommendation of Avoid.

Meagre (*Argyrosomus regius*) produced in brackish ponds and lagoons in Egypt using whole fish

Criterion	Score	Rank	Critical?
C1 Data	3.64	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	2.67	RED	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	0.00	CRITICAL	YES
C6 Escapes	5.00	YELLOW	NO
C7 Disease	2.00	RED	NO
C8X Source	-8.00	RED	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**-0.70**		
Final score (0-10)	**-0.10**		

OVERALL RANKING

Final Score	-0.10
Initial rank	RED
Red criteria	6
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary: Meagre farmed in Egypt using whole fish

The score for meagre farmed in brackish ponds and lagoons in Egypt using whole fish, is -0.10. With six Red-ranked criteria (Effluent, Habitat, Chemical Use, Feed, Disease, Source of Stock), two of which are Critical (Effluent, Feed), the final ranking is Red and a recommendation of Avoid.

Acknowledgements

Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

A number of organizations and individuals provided input into this assessment. The authors would like to thank those reviewers who chose to remain anonymous and the following (listed alphabetically by surname):

Dr. Pablo Arechavala-Lopez, Department of Ecology and Marine Resources Mediterranean Institute for Advanced Studies (IMEDEA), Spain
Izzat Feidi, Fisheries Consultant, Egypt
Dr. Shérif Sadek, Creator and manager of Aquaculture consultant Office, Egypt and President, African Chapter, World Aquaculture Society, Egypt
Dr. Philippe Sourd, Senior Veterinarian, Culmárex, Spain
Dr. John A. Theodorou, Department of Animal Production, Fisheries & Aquaculture, University of Patras, Greece
Dr. Bill Vandaele (Dr Vet Med-Lic Zoot-E.P.A-MAVC) (EU)

References

AE. 2014. Aquaculture Europe Workshop: Performance of the seabass and sea bream sector in the Mediterranean (BJORN MYRSETH), 16 October 2014. https://www.aquaeas.eu/news/311-ae2014-performance-of-the-sea-bass-and-sea-bream-sector

AG. 2019. Andromeda Group https://www.andromedagroup.eu/WHOLE-FRESH-FISH

ASOA. 2017. The Alliance to Save Our Antibiotics - Briefing paper: Real farming solutions to antibiotic misuse http://www.saveourantibiotics.org/media/1777/asoa-report-real-farming-solutions-to-antibiotic-misues-what-farmers-and-supermarkets-must-do.pdf

AU-IBAR. 2016. Mapping study of aquatic animal diseases in North Africa – North Africa. AU-IBAR Reports https://www.researchgate.net/publication/315449060_MAPPING_STUDY_OF_AQUATIC_ANIMAL_DISEASES_-_SOUTHERN_AFRICA

Abdel-Aziz M, Eissa AE, Hanna M, Okada MA. 2013. Identifying some pathogenic Vibrio/Photobacterium species during mass mortalities of cultured Gilthead seabream (Sparus aurata) and European seabass (Dicentrarchus labrax) from some Egyptian coastal provinces - International Journal of Veterinary Science and Medicine (2013) 1, 87–95 https://scholar.cu.edu.eg/sites/default/files/mmoa/files/identifying_some_pathogenic_vibrio.photobacterium_from_seabream_and_seabass_dr._mahmoud_mehani.pdf

Abdelhamid A M, Madkour FF, El-Regal AMA, Radwan AM. 2013. Profitability Analysis of Argyrosomus regius Farming in the Earthen Ponds at the Western Region of Port Said, Egypt. JOURNAL OF THE ARABIAN AQUACULTURE SOCIETY. 8. 445-454. https://www.researchgate.net/publication/263769292_Profitability_Analysis_of_Argyrosomus_regius_Farming_in_the_Earthern_Ponds_at_the_Western_Region_of_Port_Said_Egypt

Abdel-Latif HMR, Khalil RH, El-Hofi HR, Saad, TT, Zaied SMA. 2015. Epidemiological investigations of Mycotic infections of cultured Gilthead seabream, Sparus aurata at Marriott Lake, Egypt. International Journal of Fisheries and Aquatic Studies. 2. 05-13 https://www.researchgate.net/publication/269466211_Epidemiological_investigations_of_Mycotic_infections_of_cultured_Gilthead_seabream_Sparus_aurata_at_Marriott_Lake_Egypt

Abou-shabana NM, Soliman HR, Al-Absawey MA, Samira SA. 2012. Reproductive biology of Argyrosomus regius (Asso, 1801) inhabiting the south eastern Mediterranean Sea, Egypt. The Egyptian Journal of Aquatic Research. 38. 147–156. 10.1016/j.ejar.2012.12.002.

https://www.researchgate.net/publication/257681619_Reproductive_biology_of_Argyrosomus_regius_Asso_1801_inhabiting_the_south_eastern_Mediterranean_Sea_Egypt

Aguado-Giménez F, Piedecausa MA, Gutiérrez JM, García-Charton JA, Belmonte A, García-García B. 2012. Benthic recovery after fish farming cessation: A "beyond-BACI" approach - Marine Pollution Bulletin 64 (2012) 729–738
https://www.researchgate.net/requests/r42242717

Alderman DJ. 2009. Control of the use of veterinary drugs and vaccines in aquaculture in the European Union - *Options MÈditerranÈennes, A / no. 86, 2009*
The use of veterinary drugs and vaccines in Mediterranean aquaculture
http://om.ciheam.org/om/pdf/a86/00801058.pdf

Al-Monitor. 2018. Al-Monitor media website: Rising sea levels threaten Egyptian coasts – by Nadia Mabrouk December 28, 2018
https://www.al-monitor.com/pulse/originals/2018/12/coasts-environement-climate-change-egypt-floods-emergency.html

Aly SM, Albutti A. 2014. Antimicrobials Use in Aquaculture and their Public Health Impact. J Aquac Res Development 5:247. doi:10.4172/2155-9546.1000247
https://www.omicsonline.org/open-access/antimicrobials-use-in-aquaculture-and-their-public-health-impact-2155-9546.1000247.php?aid=28002

Aly SM. 2013. A review of fish diseases in the Egyptian aquaculture sector: Working report. Penang, Malaysia: WorldFish.
https://cgspace.cgiar.org/handle/10568/34870

Andromeda Group. 2018. Andromeda Group marine farm.
http://www.andromedagroup.eu

Aguilar-Manjarrez J, Soto D, Brummett R. 2017. Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. A handbook. Report ACS18071. Rome, FAO, and World Bank Group, Washington, DC. 62 pp. Includes a USB card containing the full document (395 pp.).
http://documents.worldbank.org/curated/en/421101490644362778/pdf/ACS18071-REVISED-v2-408PG-a-i6992e.pdf

AquacultureDirectory. 2018. Targeting fish parasites for a healthier aquaculture industry – July 18, 2018
http://aquaculturedirectory.co.uk/targeting-fish-parasites-for-a-healthier-aquaculture-industry/

AquaSpace. 2018a. AquaSpace Case Study Mediterranean Sea, Multiple EEZ: Issues and Tools
http://www.aquaspace-h2020.eu/?page_id=12754

AquaSpace. 2018b. Ecosystem Approach to making Space for Aquaculture EU Horizon 2020 project grant no. 633476, pp. 160-186
http://www.aquaspace-h2020.eu/wp-content/uploads/2018/09/AquaSpace-D4-2-revisedfinal-17Aug2018-1.pdf

Arechavala-Lopez P, Izquierdo-Gomez D, Forcada A, Fernandez-Jover D, Toledo-Guedes K, C. Valle C, Sanchez-Jerez P. 2018. Recapturing fish escapes from coastal farms in the western Mediterranean Sea: Insights for potential contingency plans - Ocean and Coastal Management 151 (2018) 69–76
https://www.researchgate.net/publication/320763530_Recapturing_fish_escapes_from_coastal_farms_in_the_western_Mediterranean_Sea_Insights_for_potential_contingency_plans

Arechavala-Lopez P, Toledo-Guedes K, Izquierdo-Gomez D, Šegvić-Bubić T, Sanchez-Jerez P. 2017a. Implications of Sea Bream and Seabass Escapes for Sustainable Aquaculture Management: A Review of Interactions, Risks and Consequences, Reviews in Fisheries Science & Aquaculture, Volume 26, 2018 - Issue 2
http://dx.doi.org/10.1080/23308249.2017.1384789

Arechavala-Lopez P, Uglem I, Izquierdo-Gomez D, Fernandez-Jover D, Sanchez-Jerez P. 2017b. Rapid dispersion of escaped meagre (Argyrosomus regius) from a coastal Mediterranean fish farm. Aquac. Res. 48, 1502–1512
https://www.researchgate.net/publication/290325323_Rapid_dispersion_of_escaped_meagre_Argyrosomus_regius_from_a_coastal_Mediterranean_fish_farm

Arechavala-Lopez P, Valero-Rodriguez JM, Peñalver-García J, Izquierdo-Gomez D, Sanchez-Jerez P. 2015. Linking coastal aquaculture of meagre *Argyrosomus regius* and Western Mediterranean coastal fisheries through escapes incidents. Fish Manag Ecol, 22: 317-325. doi:10.1111/fme.12129
https://onlinelibrary.wiley.com/doi/pdf/10.1111/fme.12129

Arechavala Lopez P, Izquierdo-Gomez D, Sanchez-Jerez P, Bayle-Sempere JT. 2014. Simulating escapes of farmed seabass from Mediterranean open sea cages: low recaptures by local fishermen. J. Appl. Ichthyol. 30, 185–188.
https://onlinelibrary.wiley.com/doi/abs/10.1111/jai.12357

Arechavala-Lopez P, Sanchez-Jerez P, Bayle-Sempere JT, Uglem I, Mladineo I. 2013. Reared fish, farmed escapees and wild fish stocks — a triangle of pathogen transmission of concern to Mediterranean aquaculture management. Aquacult Environ Interact 3: 153–161, 2013
http://www.int-res.com/articles/aei2013/3/q003p153.pdf

Arechavala-Lopez P, Uglem I, Fernandez-Jover D, Bayle-Sempere JT, Sanchez-Jerez P. 2012. Post-escape dispersion of farmed seabream (Sparus aurata L.) and recaptures by local fisheries in the western Mediterranean Sea. Fish. Res. 121, 126–135

https://www.researchgate.net/publication/229319614_Post-
escape_dispersion_of_farmed_seabream_Sparus_aurata_L_and_recaptures_by_local_fisheries_in_the_Western_Mediterranean_Sea

Arechavala-Lopez P, Uglem I, Fernandez-Jover D, Bayle-Sempere JT, Sanchez-Jerez P. 2011. Immediate post-escape behavior of farmed seabass (*Dicentrarchus labrax* L.) in the Mediterranean Sea. Journal of Applied Ichthyology 27: 1375-1378
https://www.researchgate.net/search.Search.html?type=publication&query=Immediate%20post-escape%20behaviour%20of%20farmed%20seabass%20(Dicentrarchus%20labrax%20L.)%20in%20the%20Mediterranean%20Sea

Armstrong S, Hargrave BT, Haya K. 2005. Antibiotic Use in Finfish Aquaculture: Modes of Action, Environmental Fate, and Microbial Resistance. 10.1007/b136017.
https://www.researchgate.net/publication/225754048_Antibiotic_Use_in_Finfish_Aquaculture_Modes_of_Action_Environmental_Fateand_Microbial_Resistance

BAP. 2018. Mediterranean Seabass, Sea Bream Producer First to be Four-Star BAP - April 24, 2018
https://bapcertification.org/blog/luckyfish/

BLI. 2014. Bird Life International: Summary of National Hunting Regulations: Egypt
http://datazone.birdlife.org/userfiles/file/hunting/HuntingRegulations_Egypt.pdf

BWI. 2019. Blue World Institute – Injured Dolphins
https://www.blue-world.org/conservation/dolphin-conservation/injured-dolphins/

Bakopoulos V, Nikolaou I, Kalovyrna N, Amirali E, Kokkoris G, Spinos E. 2015. Prevention of fish photobacteriosis. Comparison of the efficacy of intraperitoneally administered commercial and experimental vaccines. Mediterranean Marine Science, 16(2), 385-392.
doi:http://dx.doi.org/10.12681/mms.1051
https://ejournals.epublishing.ekt.gr/index.php/hcmr-med-mar-sc/article/view/12894

Balci Akova S. 2015. Aquaculture and its distribution in Turkey - JOURNAL OF AQUACULTURE ENGINEERING AND FISHERIES RESEARCH E-ISSN 2149-0236, 1(4): 160-190 (2015) doi: 10.3153/JAEFR15018 © 2015 ScientificWebJournals (SWJ)
http://www.scientificwebjournals.com/JAEFR/Vol1/issue4/JAEFR15018.pdf

Barberá C, Bordehore C, Borg JA, Glémarec, M, Grall J, Huz C, Lanfranco E, Lastra M, Moore PG, Mora J, Pita ME, Espla Alfonso A, Rizzo M, Sánchez-Mata A, Seva, A, Schembri P, Valle C. 2003. Conservation and management of NE Atlantic and Mediterranean maerl beds. Aquatic Conservation: Marine and Freshwater Ecosystems. 13. S65 - S76. 10.1002/aqc.569.

https://www.researchgate.net/publication/227958465_Conservation_and_management_of_NE_Atlantic_and_Mediterranean_maerl_beds

Barsøe S. 2018. Prophylactic measures against Viral Encephalopathy and Retinopathy (VER) and vaccine development. http://www.medaid-h2020.eu/index.php/2018/09/07/prophylactic-measures-against-viral-encephalopathy-and-retinopathy-ver-and-vaccine-development/

Basaran AK, Aksu M, Egemen O. 2010. Impacts of the fish farms on the water column nutrient concentrations and accumulation of heavy metals in the sediments in the eastern Aegean Sea (Turkey). Environmental Monitoring and Assessment 162: 439–451.
https://www.researchgate.net/publication/24040102ImpactsofthefishfarmsonthewatercolumnnutrientconcentrationsandaccumulationofheavymetalsinthesedimentsintheeasternAegeanSeaTurkey

Bascinar NS, Gozler AM, Şahin C, Eruz Ç, Tolun L, Agirbas E, Mantikci M, Serdar S, Verep B. 2014. The impact assessment of cage aquaculture on benthic communities along the south eastern Black Sea - Iranian Journal of Fisheries Sciences, 12(3), 2013
https://jifro.ir/article-1-1729-fa.pdf

Bearzi G, Fortuna C, Reeves R. 2012. *Tursiops truncatus Mediterranean subpopulation*. *The IUCN Red List of Threatened Species* 2012: e.T16369383A16369386. http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T16369383A16369386.en. Downloaded on 13 September 2019
https://www.iucnredlist.org/species/16369383/16369386

Benchmark. 2016. Benchmark's new seabass vaccine commences commercial field trials – 19 July 2016
http://www.benchmarkplc.com/articles/benchmarks-new-seabass-vaccine-commences-commercial-field-trials

Berzak R, Scheinin A, Davidovich N, Regev Y, Diga R, Tchernov D, Morick D. 2019. Prevalence of nervous necrosis virus (NNV) and Streptococcus species in wild marine fish and crustaceans from the Levantine Basin, Mediterranean Sea. Dis Aquat Org 133:7-17. https://doi.org/10.3354/dao03339
https://www.researchgate.net/publication/330084137_Prevalence_of_nervous_necrosis_virus_NNV_and_Streptococcus_species_in_wild_marine_fish_and_crustaceans_from_the_Levantine_Basin_Mediterranean_Sea

Biomar. 2018. Feed specification sheets for seabream, seabass and meagre grower diets
http://www.biomar.com/globalassets/.global/pdf-files-_en/datasheets-_en/seabream/gb-gr-efico-kappa-493-3-8-mm-seabream.pdf
http://www.biomar.com/globalassets/.global/pdf-files-_en/datasheets-_en/-greece/seabass/gb-gr-efico-kappa-497-3-8-mm-sea-bass.pdf

http://www.biomar.com/globalassets/.global/pdf-files-_en/datasheets-_en/meagre/gb-gr-efico-sigma-415-meagre.pdf

Bissattini AM, Traversetti L, Bellavia G, Scalici M. 2015. Tolerance of Increasing Water Salinity in the Red Swamp Crayfish *Procambarus Clarkii* (), *Journal of Crustacean Biology*, Volume 35, Issue 5, 1 September 2015, Pages 682–685, https://doi.org/10.1163/1937240X-00002366 https://academic.oup.com/jcb/article/35/5/682/2547968

Black KD, Pearson TH, Kögeler JW, Thetmeyer H, Karakassis I, White PG. 2002. MERAMED: Development of monitoring guidelines and modelling tools for environmental effects from Mediterranean aquaculture1.
https://www.researchgate.net/publication/237704310_MERAMED_Development_of_monitoring_guidelines_and_modelling_tools_for_environmental_effects_from_Mediterranean_aquaculture1

Bodur T, Günaydın CO, Toplu S. 2014. A Preliminary Research on Meagre (*Argyrosomus Regius*, Asso 1801) Culture in Earthen Pond During Summer Season in Turkey - Aquaculture Europe Workshop: Donostia–San Sebastián, Spain.
https://www.was.org/easonline/AbstractDetail.aspx?i=3667

Bonizzoni S, Furey N, Pirotta E, & Valavanis, VD, Würsig B, Bearzi G. 2014. Fish farming and its appeal to common bottlenose dolphins: Modelling habitat use in a Mediterranean embayment. Aquatic Conservation Marine and Freshwater Ecosystems. 24. 10.1002/aqc.2401.
https://www.researchgate.net/publication/257237258_Fish_farming_and_its_appeal_to_common_bottlenose_dolphins_Modelling_habitat_use_in_a_Mediterranean_embayment

Borecka M, Siedlewicz G, Haliński Ł, Sikora K, Pazdro K, Stepnowski P, Białk-Bielińska A. 2015. Contamination of the southern Baltic Sea waters by the residues of selected pharmaceuticals: Method development and field studies. Marine Pollution Bulletin. 26. 10.1016/j.marpolbul.2015.03.008.
https://www.researchgate.net/publication/274096963_Contamination_of_the_southern_Baltic_Sea_waters_by_the_residues_of_selected_pharmaceuticals_Method_development_and_field_studies

Boxall, A.B.A., Fogg, L., Blackwell, P.A., Kay, P.A.P., Pemberton, E.J. 2002. Review of veterinary medicines in the environment. R&D Technical Report P6-012/8/TR. United Kingdom, Environment Agency, Bristol.

Brigolin D, Pranovi F, Kholeif S, Abdelsalam K, Pastres R. 2016. Interactions of cage aquaculture in Nile Delta lakes: Insights from field data and models. Regional Studies in Marine Science (2016), http://dx.doi.org/10.1016/j.rsma.2016.06.002
https://www.researchgate.net/publication/304143739_Interactions_of_cage_aquaculture_in_Nile_Delta_lakes_Insights_from_field_data_and_models

Brown C, Miltiadou D, Tsigenopoulos CS. 2015. Prevalence and survival of escaped European seabass Dicentrarchus labrax in Cyprus identified using genetic markers. Aquaculture Environment Interactions, 7: 49–59.
https://www.int-res.com/articles/aei2015/7/q007p049.pdf

Brugère C, Aguilar-Manjarrez J, Beveridge MCM, Soto D. 2018. The ecosystem approach to aquaculture 10 years on – a critical review and consideration of its future role in blue growth - Reviews in Aquaculture (2018) 0, 1–22
https://onlinelibrary.wiley.com/doi/full/10.1111/raq.12242

Buonocore F, Nuñez Ortiz N, Picchietti S, Randelli E, Stocchi V, Guerra L, Toffan A, Pascoli F, Fausto A, Mazzini M, Scapigliati G. 2017. Vaccination and immune responses of European seabass (Dicentrarchus labrax L.) against betanodavirus. Fish & Shellfish Immunology. 10.1016/j.fsi.2017.11.039.
https://www.researchgate.net/publication/321263710_Vaccination_and_immune_responses_of_European_sea_bass_Dicentrarchus_labrax_L_against_betanodavirus

Burridge, L.E., Lyons, M.C., Wong, D.K.H., MacKeigan, K., VanGeest, J.L. 2014. The acute lethality of three anti-sea lice formulations: AlphaMax®, Salmosan®, and Interox®Paramove™50 to lobster and shrimp. Aquaculture 420–421, 180–186.
Burridge, L.E., Weis, J.S., Cabello, F., Pizarro, J., Bostik, K. 2010. Chemical use in salmon aquaculture: a review of current practices and possible environmental effects. Aquaculture 306, 7–23.

CARE. 2014. The Issuance of the Amended Constitution of the Arab Republic of Egypt -January 24- 15 2014
http://extwprlegs1.fao.org/docs/pdf/egy127542e.pdf

CVMP. 2016. Committee for Medicinal Products for Veterinary Use (CVMP) Guideline on environmental impact assessment for veterinary medicinal products in support of the VICH guidelines GL6 and GL38 EMA/CVMP/ERA/418282/2005 © European Medicines Agency, 2016
https://www.ema.europa.eu/en/documents/scientific-guideline/guideline-environmental-impact-assessment-veterinary-medicinal-products-support-vich-guidelines-gl6_en.pdf

Cabello F, Godfrey H, Tomova A, Ivanova L, Dölz H, Millanao A, & Buschmann A. 2013. Antimicrobial use in aquaculture re-examined: Its relevance to antimicrobial resistance and to animal and human health. Environmental microbiology. 15. 10.1111/1462-2920.12134.
https://www.researchgate.net/publication/236947544_Antimicrobial_use_in_aquaculture_re-examined_Its_relevance_to_antimicrobial_resistance_and_to_animal_and_human_health

Çagirgan H. 2009. The use of veterinary drugs and vaccines in Turkey. In: Rogers C. (ed.), Basurco B. (ed.). The use of veterinary drugs and vaccines in Mediterranean aquaculture. Zaragoza: CIHEAM, 2009. p. 29-34 (Options Méditerranéennes: Série A. Séminaires Méditerranéens; n. 86) http://om.ciheam.org/om/pdf/a86/00801059.pdf

Cardia F, Lovatelli A. 2007. A review of cage aquaculture: Mediterranean Sea, pp. 156–187. In: Cage Aquaculture – Regional Reviews and Global Overview, FAO Fisheries Technical Paper. No. 498 (Halwart, M., Soto, D., and Arthur, J.R. Eds.). Rome: FAO (2007).
http://www.fao.org/3/a1290e/a1290e07.pdf

Caruso G. 2016. Antibiotic Resistance in Fish Farming Environments: A Global Concern - Journal of FisheriesSciences.com E-ISSN 1307-234X - 10(4): 9-13 (2016)
https://pdfs.semanticscholar.org/0513/d6c18e070643afc71b8cd310a568e27db242.pdf

Castric J, Thiéry R, Jeffroy J, de Kinkelin P, Raymond JC. 2011. Sea bream Sparus aurata, an asymptomatic contagious fish host for nodavirus - Dis Aquat Org 47: 33–38, 2001
https://www.int-res.com/articles/dao/47/d047p033.pdf

Cataudella S, Crosetti D, Massa F. 2015. Mediterranean coastal lagoons: sustainable management and interactions among aquaculture, capture fisheries and the environment. Studies and Reviews - General Fisheries Commission for the Mediterranean. No. 95. Rome, FAO. 2015. 278 pp.
http://www.fao.org/3/a-i4668e.pdf

Cengizler I, Aytac N, Aldik R. 2017. Biocide Use and its Potential Risks in Aquaculture in Turkey, Eastern Anatolian Journal of Science, Vol. 3, Issue 1, 1-5, 2017.
http://dergipark.gov.tr/download/article-file/300793

Chavanne H, Janssen K, Hofherr J, Contini F, Haffray P, Komen H, Nielsen EE, Bargelloni L & Aquatrace Consortium. 2016. A comprehensive survey on selective breeding programs and seed market in the European aquaculture fish industry. Aquaculture International. 24. 10.1007/s10499-016-9985-0.
https://link.springer.com/article/10.1007/s10499-016-9985-0

Chaves-Pozo E, Guardiola F, Meseguer J, Esteban M, Cuesta A. 2012. Nodavirus infection induces a great innate cell-mediated cytotoxic activity in resistant, gilthead seabream, and susceptible, European seabass, teleost fish. Fish & shellfish immunology. 33. 1159-66. 10.1016/j.fsi.2012.09.002.
https://www.researchgate.net/publication/230862575_Nodavirus_infection_induces_a_great_innate_cell-mediated_cytotoxic_activity_in_resistant_gilthead_seabream_and_susceptible_European_sea_bass_teleost_fish

Cherif N, Fatma A. 2017. Nodaviruses in Wild Fish Population Collected Around Aquaculture Cage Sites from Coastal Areas of Tunisia. Fish Aqua J 8: 209. doi:10.4172/2150-3508.1000209
https://www.longdom.org/open-access/nodaviruses-in-wild-fish-population-collected-around-aquaculture-cage-sites-from-coastal-areas-of-tunisia-2150-3508-1000209.pdf

Cidad M, Peral I, Ramos S, Basurco B, López-Francos A, Muniesa ., Cavallo M, Pére, J, Aguilera C, Furones D, Reverté C, Sanjuan-Vilaplana A, Brun E, Jansen MD, Tavornpanich S, Raux P, Baraibar E, Cobo A, Fernández-Polanco JM, Llorente I, Fernández Sánchez JL., Luna M, Luna L, Odriozola M, Gulzari B, Janssen K, Komen H. 2018. Assessment of Mediterranean Aquaculture Sustainability. Deliverable 1.2 of the Horizon 2020 project MedAID (GA number 727315), published in the project web site on 21.12.2018: http://www.medaid-h2020.eu/index.php/deliverables/
https://drive.google.com/file/d/1lE5Min96Ve2MJ8T0zaZkl6IYYCtscY6v/view

Çinar M, Ergen Z & Dagli E. 2004. Effects of fish farming on the distribution of polychaetes in the Aegean Sea, conference paper
https://www.researchgate.net/publication/251572575EffectsoffishfarmingonthedistributionofpolychaetesintheAegeanSea

Conti GO, Copat C, Wang Z, D'Agati P, Cristaldi A, Ferrante M. 2015. Determination of illegal antimicrobials in aquaculture feed and fish: An ELISA study - Food Control 50 (2015) 937e941
https://www.sciencedirect.com/science/article/pii/S095671351400632X

Costa JZ, Thompson KD. 2016. Understanding the interaction between Betanodavirus and its host for the development of prophylactic measures for viral encephalopathy and retinopathy. Fish & Shellfish Immunology, 53, 35–49. https://doi.org/10.1016/j.fsi.2016.03.033
https://www.sciencedirect.com/science/article/pii/S1050464816301127?via%3Dihub

Costello, M.J., Grant, A., Davies, I.M., Cecchini, S., Papoutsoglou, S., Quigley, D., Saroglia,M. 2001. The control of chemicals used in aquaculture in Europe. J. Appl. Ichthyol. 17, 173–180.

Crespi V, Lovatelli A. 2011. *Aquaculture in desert and arid lands: development constraints and opportunities.* FAO Technical Workshop. 6–9 July 2010, Hermosillo, Mexico. FAO Fisheries and Aquaculture Proceedings No. 20. Rome, FAO. 2011. 202 pp.
http://www.fao.org/docrep/015/ba0114e/ba0114e.pdf

Cromey CJ, Thetmeyer H, Lampadariou N, Black KD, Kögeler JW, Karakassis I. 2012. MERAMOD: predicting the deposition and benthic impact of aquaculture in the eastern Mediterranean Sea - Aquacult Environ Interact 2: 157–176, 2012
https://pdfs.semanticscholar.org/b419/3922148f6aece3fe5e039ae2a4a74e0c9709.pdf

Crosetti D, & Rossi AR, De Innocentiis S. 2014. GIlthead sea bream (Sparus aurata) - AquaTrace Species leaflet. D.Crosetti, AR. Rossi, S. de Innocentiis (eds)
https://www.researchgate.net/publication/283906826_GIlthead_sea_bream_Sparus_aurata_-_AquaTrace_Species_leaflet_DCrosetti_AR_Rossi_S_de_Innocentiis_eds_httpsaquatraceeudocuments80305142567giltheadseabreamleafletpdf

Culmárex. 2018. (Spain's largest producer of seabass and seabream)
http://www.culmarex.com/en
DFMR. 2018. Cyprus Department of Fisheries and Marine Research.
http://www.moa.gov.cy/moa/dfmr/dfmr.nsf/All/CF42DB069283278342257E960035E13B?OpenDocument

DailyNews. 2010. Daily News – Egypt. Wadi goes fishing in Egypt's desert, August 26 2010
https://www.dailynewsegypt.com/2010/08/26/wadi-goes-fishing-in-egypts-desert/

Dalsgaard T, Krause-Jensen D. 2006. Monitoring nutrient release from fish farms with macroalgal and phytoplankton bioassays. Aquaculture., 256: 302–310.
https://www.sciencedirect.com/science/article/abs/pii/S0044848606001499

Daniel P. 2009. Available chemotherapy in Mediterranean fish farming: use and needs. In: Rogers C. (ed.), Basurco B. (ed.). The use of veterinary drugs and vaccines in Mediterranean aquaculture. Zaragoza: CIHEAM, 2009. p. 197-205 (Options Méditerranéennes: Série A. Séminaires Méditerranéens; n. 86)
http://om.ciheam.org/om/pdf/a86/00801072.pdf

Dempster T, Sanchez-Jerez P. 2008. Aquaculture and Coastal Space Management in Europe: An Ecological Perspective (Chapter 3) - Aquaculture and Coastal Space Management - M. Holmer et al. (eds.), *Aquaculture in the Ecosystem.* 87 © 2008 Springer
https://www.researchgate.net/publication/226596819_Aquaculture_and_Coastal_Space_Management_in_Europe_An_Ecological_Perspective

Diaz-Almela E, Marba N, Alvarez E, Santiago R, Holmer M, Grau A, Mirto S, Danavaro R, Petrou A, Argyrou M, Karakassis I, Duarte CM. 2008. Benthic input rates predict seagrass (*Posidonia oceanica*) fish farm-induced decline. Marine Pollution Bulletin 56: 1332–1342
http://uicnmed.org/bibliotecavirtualposidonia/wp-content/uploads/2014/04/Benthic-input-rates-predict-seagrass-Posidonia-oceanica-fish-piscifactorias.pdf

Díaz López B. 2017. Temporal variability in predator presence around a fin fish farm in the Northwestern Mediterranean Sea. Marine Ecology. 38. e12378. 10.1111/maec.12378
https://www.researchgate.net/publication/313740589_Temporal_variability_in_predator_presence_around_a_fin_fish_farm_in_the_Northwestern_Mediterranean_Sea

Díaz López B. 2012. Bottlenose dolphins and aquaculture: Interaction and site fidelity on the north-eastern coast of Sardinia (Italy). Marine Biology. 159. 2161-2172. 10.1007/s00227-012-2002-x.
https://www.researchgate.net/publication/232707131_Bottlenose_dolphins_and_aquaculture_Interaction_and_site_fidelity_on_the_north-eastern_coast_of_Sardinia_Italy

Díaz López B. 2007. The pressures of aquaculture and gillnets fisheries on coastal bottlenose dolphins off Sardinia - The Bottlenose Dolphin Research Institute – BDRI, Via Diaz 4, 07020 Golfo Aranci (SS) Italy
https://www.researchgate.net/profile/Bruno_Diaz_Lopez/publication/317033822_The_pressures_of_aquaculture_and_gillnets_fisheries_on_coastal_bottlenose_dolphins_off_Sardinia/links/592062ff0f7e9b99793fc80c/The-pressures-of-aquaculture-and-gillnets-fisheries-on-coastal-bottlenose-dolphins-off-Sardinia.pdf

Díaz López B. & Shirai JAB. 2007. Bottlenose dolphin (Tursiops truncatus) presence and incidental capture in a marine fish farm on the north-eastern coast of Sardinia (Italy). Journal of the Marine Biological Association of the United Kingdom. 87. 113 - 117. 10.1017/S0025315407054215.
https://www.researchgate.net/publication/232013558_Bottlenose_dolphin_Tursiops_truncatus_presence_and_incidental_capture_in_a_marine_fish_farm_on_the_north-eastern_coast_of_Sardinia_Italy

Douet DG, Le Bris H, Giraud E. 2009. Environmental aspects of drug and chemical use in aquaculture: an overview. In: Rogers C. (ed.), Basurco B. (ed.). *The use of veterinary drugs and vaccines in Mediterranean aquaculture*. Zaragoza: CIHEAM, 2009. p. 105-126. (Options Méditerranéennes: Série A. Séminaires Méditerranéens; n. 86). The Use of Veterinary Drugs and Vaccines in Mediterranean Aquaculture, 2003/05/21-23, Izmir (Turkey).
http://om.ciheam.org/om/pdf/a86/00801066.pdf

Duncan NJ, Estévez A, Fernández-Palacios H, Gairin I, Hernández-Cruz CM, Roo J, Schuchardt D, Vallés, R. 2013. Aquaculture production of meagre (*Argyrosomus regius*): hatchery techniques, ongrowing and market. In: Allan, G., Burnell, G. (Eds.), Advances in aquaculture hatchery technology. Woodhead Publishing Limited, Cambridge, UK.
https://www.researchgate.net/publication/235951552_Aquaculture_production_of_meagre_Argyrosomus_regius_Hatchery_techniques_ongrowing_and_market

EAS. 2015. European Aquaculture Society. Advances in meagre *(Argyrosomus regius)* Research during the first year of the project "Diversify". Aquaculture Europe, Vol. 40 (1) March 2015
https://www.diversifyfish.eu/uploads/1/4/2/0/14206280/aes-vol40-1-mar2015_low.pdf

EC. 2019. European Commission: Our Oceans, Seas and Coasts - Legislation: the Marine Strategy Framework Directive
http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

EC. 2018a. European Commission - Clean, healthy and productive seas
http://ec.europa.eu/environment/marine/pdf/27092017newsen.pdf

EC. 2018b. European Commission – European Seabass factsheet
https://ec.europa.eu/fisheries/marine_species/farmed_fish_and_shellfish/seabass/

EC. 2018c. European Commission – European Seabream factsheet
https://ec.europa.eu/fisheries/marine_species/farmed_fish_and_shellfish/seabream_en

EC. 2017. European Commission - Farmed in the EU.
https://ec.europa.eu/fisheries/inseparable/en/farmed-eu#quicktabs-farmingintheeuen=1

EC. 2016. European Commission Staff Working Document: On the application of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) in relation to aquaculture - Brussels, 18.5.2016 SWD (2016) 178 final
http://ec.europa.eu/environment/marine/pdf/SWD_2016_178.pdf

EC. 2013. Regulation (EU) No. 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No. 1954/2003 and (EC) No. 1224/2009 and repealing Council Regulations (EC) No. 2371/2002 and (EC) No. 639/2004 and Council Decision 2004/585/EC
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R1380&from=EN

EC. 2012. European Commission - Guidance document on aquaculture activities in the Natura 2000 Network: Guidance on Aquaculture and Natura 2000 - Sustainable aquaculture activities in the context of the Natura 2000 Network
http://ec.europa.eu/environment/nature/natura2000/management/docs/Aqua-N2000%20guide.pdf

EC. 2009. European Commission - Criteria and thresholds for requiring an Environmental Impact Assessment in aquaculture
https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/environmental-impact-assessment-in-aquaculture_en.pdf

EEA. 2018. European Environment Agency - Aquaculture production: Indicator Specification| Data and maps
https://www.eea.europa.eu/downloads/36075c061367424fb72ce0ae3f7741da/1547716041/aquaculture-production-4.pdf

EI. 2012. Egypt Independent - Fishermen blame aquaculture for diminishing wild fry population - February 24, 2012
https://www.egyptindependent.com/fishermen-blame-aquaculture-diminishing-wild-fry-population/

ESVAC. 2019. European Medicines Agency, European Surveillance of Veterinary Antimicrobial Consumption, 2019. 'Sales of veterinary antimicrobial agents in 31 European countries in 2017'. (EMA/294674/2019) https://www.ema.europa.eu/en/documents/report/sales-veterinary-antimicrobial-agents-31-european-countries-2017_en.pdf

EU. 2018a. European Parliament resolution of 12 June 2018 on towards a sustainable and competitive European aquaculture sector: current status and future challenges (2017/2118(INI) http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2018-0248+0+DOC+XML+V0//EN&language=EN

EU. 2018b. REGULATION (EU) 2019/6 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on veterinary medicinal products and repealing Directive 2001/82/EC https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019R0006&from=EN

EU. 2018c. OVERVIEW REPORT ON MEASURES TO TACKLE ANTIMICROBIAL RESISTANCE (AMR) THROUGH THE PRUDENT USE OF ANTIMICROBIALS IN ANIMALS –
Published: 2018-03-21 Corporate author(s): Directorate-General for Health and Food Safety (European Commission)
https://publications.europa.eu/en/publication-detail/-/publication/aa676ddd-2d87-11e8-b5fe-01aa75ed71a1/language-en

EU. 2017. European Union: Environmental Impact Assessment of Projects - Guidance on Screening (Directive 2011/92/EU as amended by 2014/52/EU) doi:10.2779/875365 http://ec.europa.eu/environment/eia/pdf/EIA_guidance_Screening_final.pdf

EU. 2016. European Union: Facts and figures on the Common Fisheries Policy - Basic statistical data, 2016 EDITION (p 28 - Top 10 species in aquaculture in the European Union (2013) https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/pcpen.pdf

EU. 2015. European Union: Overview report: Implementation of the Rules on Finfish Aquaculture - DG Health and Food Safety. Luxembourg: Publications Office of the European Union, 2015.
http://ec.europa.eu/food/audits-analysis/overview_reports/details.cfm?rep_id=95

EU. 2014a. The economic performance of the EU aquaculture sector (STECF 14-18). Scientific, Technical and Economic Committee for Fisheries (STECF). 2014. Publications Office of the European Union, Luxembourg, EUR 27033 EN, JRC 93169, 451 pp.
https://publications.europa.eu/en/publication-detail/-/publication/7f92a400-c86d-4dad-8689-586d33cc17d4/language-en

EU. 2014b. Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 - Establishing a Framework for Maritime Spatial Planning https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014L0089&from=EN

EU. 2009a. Regulatory and Legal Constraints for European Aquaculture - Directorate General for Internal Policies Policy Department B: Structural and Cohesion Policies - Fisheries http://www.europarl.europa.eu/RegData/etudes/etudes/join/2009/431568/IPOL-PECHET%282009%29431568EN.pdf

EU. 2009b. Protocol on Integrated Coastal Zone Management in the Mediterranean - EU Official Journal L34/19, 4 Feb 2009
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:22009A0204(01)&from=EN

EU. 2009c. DIRECTIVE 2009/147/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 November 2009 on the conservation of wild birds
https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009L0147&from=EN

EU. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31992L0043&from=EN

EUMOFA. 2017. European Market Observatory for Fisheries and Aquaculture Products – EU Organic Aquaculture – May 2017
http://www.eumofa.eu/documents/20178/84590/Study+report_organic+aquaculture.pdf

EURL. 2017. European Union Reference Laboratory for Fish Diseases: Report on Survey and Diagnosis of Fish Diseases in Europe 2017 – published 22. October 2018
http://www.eurl-fish.eu//-/media/Sites/EURL-FISH/english/activities/survey-and-diagnosis/2018/Report-on-Survey-and-Diagnosis-of-Fish-Diseases-in-Europe-2017.ashx

EURL. 2016. European Union Reference Laboratory for Fish Diseases: Report on Survey and Diagnosis of Fish Diseases in Europe 2016 – published 12. June 2017
http://www.eurl-fish.eu//-/media/Sites/EURL-FISH/english/activities/survey-and-diagnosis/2017/Report-on-Survey-and-Diagnosis-of-Fish-Diseases-in-Europe-2016.ashx

EURL. 2015. European Union Reference Laboratory for Fish Diseases: Report on Survey and Diagnosis of Fish Diseases in Europe 2015 – published 28. September 2016
http://www.eurl-fish.eu//-/media/Sites/EURL-FISH/english/activities/survey-and-diagnosis/2016/Report-on-Survey-and-Diagnosis-of-Fish-Diseases-in-Europe-2015-plus-annex-17-06.ashx

EgyLaw4. 1994. Law Number 4 of 1994 Promulgating the Environment Law, Egypt, and its Executive Regulation
http://extwprlegs1.fao.org/docs/pdf/egy4984E.pdf

EgyptToday. 2017. Authorities clean 3.2M sqm of Manzala Lake in Damietta - Wed, Jul. 19, 2017
http://www.egypttoday.com/Article/1/12702/Authorities-clean-3-2M-sqm-of-Manzala-Lake-in-Damietta

Eid AR, Hoballah EM, Mosa SEA. 2014. Sustainable Management of Drainage Water of Fish Farms in Agriculture as a New Source for Irrigation and Bio-Source for Fertilizing. *Agricultural Sciences*, **5**, 730-742.
https://file.scirp.org/pdf/AS_2014072814344202.pdf

Eissa AE, Moustafa M, Abumhara A, Hosni M. 2016. Future Prospects of Biosecurity Strategies in Egyptian Fish Farms. Journal of Fisheries and Aquatic Science, 11: 100-107.
https://scialert.net/fulltextmobile/?doi=jfas.2016.100.107

Eissa AE, Hussein HA, Hussein, Zaki MM. 2012. Detection of Avian Influenza (H5N1) In Some Fish and Shellfish from Different Aquatic Habitats across Some Egyptian Provinces. Life Science Journal. 9. 2702-2712.
https://www.researchgate.net/publication/278096731_Detection_of_Avian_Influenza_H5N1_In_Some_Fish_and_Shellfish_from_Different_Aquatic_Habitats_across_Some_Egyptian_Provinces

El-Atta MEA. 2013. Some Bacterial and Fungal affections Causing Disease Problems in Cultured Seabream Sparus Aurata in Damietta Governorate and Trials for Control - JOURNAL OF THE ARABIAN AQUACULTURE SOCIETY Vol. 8 No. 2 Arabian Aquaculture Conference
http://www.arabaqs.org/journal/vol_8/2/Text%2013-34.pdf

El-Amier YA, Elnaggar AA, El-Alfy MA. 2016. Investigation of Eutrophication state of Manzala and Burullus lakes in Egypt by using remote sensing and GIS, J. Env. Sci. Pollut. Res. 2(4) (2016) 121–125
https://pdfs.semanticscholar.org/aeaf/08b85ae96c36b2a8c73af9f22e8889eba095.pdf?_ga=2.32292861.2138244607.1560168211-996809057.1560168211

El-Barbary MI. 2010. *Some clinical, microbiological and molecular characteristics of Aeromonas hydrophila isolated from various naturally infected fishes. Aquaculture International, 18(5), 943–954.*doi:10.1007/s10499-009-9315-x
https://www.researchgate.net/publication/226445903_Some_clinical_microbiological_and_molecular_characteristics_of_Aeromonas_hydrophila_isolated_from_various_naturally_infected_fishes

El-Gamal AR. 2018. Development and outlook of Egyptian aquaculture (mode of development - regional & global perspective – challenges - outlook) – Fish Consulting Group
http://fishconsult.org/wp-content/uploads/2018/07/Development-and-outlook-of-Egyptian-aquaculture-2018.pdf

Elkesh A, Kantham KPL, Shinn AP, Crumlish M, Richards, RH. 2012. Systemic nocardiosis in a Mediterranean population of cultured meagre, Argyrosomus regius Asso (Perciformes: Sciaenidae). Journal of fish diseases. 36. 10.1111/jfd.12015.
https://www.researchgate.net/publication/232698166_Systemic_nocardiosis_in_a_Mediterranean_population_of_cultured_meagre_Argyrosomus_regius_Asso_Perciformes_Sciaenidae

El-Mezayen M, Rueda D, Essa M, Muller-Karger FE, Elghobashy AE. 2018. Water quality observations in the marine aquaculture complex of the Deeba Triangle, Lake Manzala, Egyptian Mediterranean coast. Environmental Monitoring and Assessment. 190. 10.1007/s10661-018-6800-6.
https://www.researchgate.net/publication/326010701_Water_quality_observations_in_the_marine_aquaculture_complex_of_the_Deeba_Triangle_Lake_Manzala_Egyptian_Mediterranean_coast/citations

El-Sayed H & Karachle PK. 2017. The Marine Ichthyofauna of Egypt. Egyptian Journal of Aquatic Biology & Fisheries. 21. 81-116. 10.21608/ejabf.2017.4130.
https://www.researchgate.net/publication/320763495_The_Marine_Ichthyofauna_of_Egypt

El-Sayed A-FM. 2016. The Nile Delta, Hdb Env Chem, DOI 10.1007/698_2016_54, © Springer International Publishing Switzerland 2016
https://link.springer.com/chapter/10.1007/698_2016_54

El-Sayed A FM. 2014. Value chain analysis of the Egyptian aquaculture feed industry. WorldFish, Penang, Malaysia. Project Report: 2014-22.
https://core.ac.uk/download/pdf/33719342.pdf

Eltholth M, Fornace K, Häsler B, Rushton J. 2014. Rapid Integrated Assessment of Nutrition and Health Risks Associated with Tilapia Value Chains in Egypt
https://cgspace.cgiar.org/bitstream/handle/10568/52234/HealthRisks%20-%20TilapiaVC-Egypt.pdf;sequence=1

Encarnação P. 2016. Overview of Portuguese Aquaculture.
http://www.wavec.org/content/files/PedroEncarnao2.pdf

Essam H, & Abdellrazeq G, Tayel SI Torky H, Fadel A. 2016. Pathogenesis of Photobacterium damselae subspecies infections in seabass and sea bream. Microbial Pathogenesis. 99. 10.1016/j.micpath.2016.08.003.
https://www.researchgate.net/publication/305848583_Pathogenesis_of_Photobacterium_damselae_subspecies_infections_in_sea_bass_and_sea_bream

Eurofish. 2018. Overview of the fisheries and aquaculture sector in Eurofish member countries.
https://www.eurofish.dk/member-countries

Eurofish. 2014. Aquaculture highlights from the Mediterranean and the Black Sea
https://www.eurofish.dk/index.php/shop/aquculture-highlights-from-the-mediterranean-and-black-sea-as-pdf-file

European Parliament. 2018. European Aquaculture Fact Sheet
http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuId=FTU3.3.7.html
Eurostat. 2018a. European Aquaculture Statistics Explained.

http://ec.europa.eu/eurostat/statistics-explained/index.php/Aquaculturestatistics

Eurostat. 2018b. European statistics.
http://ec.europa.eu/eurostat/web/fisheries/data/database

FAO. 2019. Fishery and Aquaculture Statistics. Global production by production source 1950-2017 (FishstatJ). In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 2019.
http://www.fao.org/fishery/statistics/software/fishstatj/en

FAO. 2018a. Fishery and Aquaculture Statistics. Global aquaculture production 1950-2016 (FishstatJ). In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 2018
FAO. 2018b. *The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals.* Rome. Licence: CC BY-NC-SA 3.0 IGO.
http://www.fao.org/3/i9540en/I9540EN.pdf

FAO. 2018c. FAO AFFRIS Home: Aquaculture Feed and Fertilizer Resources Information System – Fisheries Species
http://www.fao.org/fishery/affris/species-profiles/en/

FAO. 2017a. Fishery and Aquaculture Statistics. Global aquaculture production 1950-2015 (FishstatJ). In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 2017.

FAO. 2017b. Regional Review on Status and Trends in Aquaculture Development in the Near East and North Africa – 2015, by Abdel-Fattah M. El-Sayed. FAO Fisheries and Aquaculture Circular No. 1135/6. Rome, Italy.
http://www.fao.org/3/a-i6876e.pdf

FAO. 2016. *The State of Mediterranean and Black Sea Fisheries 2016.* General Fisheries Commission for the Mediterranean (GFCM). Rome.
http://www.fao.org/3/a-i5496e.pdf

FAO. 2014. *Regional Conference "Blue Growth in the Mediterranean and the Black Sea: developing sustainable aquaculture for food security", 9–11 December 2014, Bari, Italy,* edited by Fabio Massa, Riccardo Rigillo, Dominique Bourdenet, Davide Fezzardi, Aurora Nastasi, Hélène Rizzotti, Wasseem Emam and Coline Carmignac. FAO Fisheries and Aquaculture Proceedings No. 46. Rome.
http://www.fao.org/3/a-i6902e.pdf

FAO. 2010. National Aquaculture Sector Overview. Egypt. National Aquaculture Sector Overview Fact Sheets. Text by Salem, A.M.; Saleh, M.A. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 16 November 2010. [Cited 25 April 2018].
http://www.fao.org/fishery/countrysector/naso_egypt/en

FAO. 2009. Environmental impact assessment and monitoring in aquaculture. *FAO Fisheries and Aquaculture Technical Paper.* No. 527. Rome, FAO. 2009. 57p. http://www.fao.org/docrep/012/i0970e/i0970e.pdf

FAO. 2005-2018a. National Aquaculture Legislation Overview. National Aquaculture Legislation Overview (NALO) Fact Sheets. Text by Olivert, A.A. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 16 May 2005. [Cited 16 April 2018]. http://www.fao.org/fishery/collection/nalo/en

FAO. 2005-2018b. Cultured Aquatic Species Information Programme. Argyrosomus regius. Cultured Aquatic Species Information Programme. Text by Stipa, P.; Angelini, M. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 10 February 2005. [Cited 17 July 2018].
http://www.fao.org/fishery/culturedspecies/Argyrosomus_regius/en

FAO. 2005a. Cultured Aquatic Species Information Programme. Sparus *aurata*. Cultured Aquatic Species Information Programme. Text by Colloca F, Cerasi S. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 8 February 2005. [Cited 29 March 2018] http://www.fao.org/fishery/culturedspecies/Sparus_aurata/en

FAO. 2005b. Cultured Aquatic Species Information Programme. *Dicentrarchus labrax*. Cultured Aquatic Species Information Programme. Text by Bagni M. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 18 February 2005. [Cited 29 March 2018] http://www.fao.org/fishery/culturedspecies/Dicentrarchus_labrax/en

FAO. 2005c. Cultured Aquatic Species Information Programme. *Argyrosomus regius*. Cultured Aquatic Species Information Programme. Text by Stipa P, Angelini M. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 10 February 2005. [Cited 29 March 2018]. http://www.fao.org/fishery/culturedspecies/Argyrosomus_regius/en

FAO-GFCM. 2017. *GFCM High-level conference towards enhanced cooperation on Black Sea fisheries and aquaculture: A declaration to boost regional cooperation in the sector, 24–25 October 2016, Bucharest, Romania,* edited by Abdellah Srour, Fabio Massa, Miguel Bernal, Nicola Ferri, Dominique Bourdenet, Margherita Sessa, Anna Carlson, Julia Pierraccini and Ahmed Siliman. FAO Fisheries and Aquaculture Proceedings No. 52. Rome, Italy. http://www.fao.org/3/a-i7109e.pdf

FAO-GFCM. 2013. Training Workshop on site selection, allocated zones for aquaculture and site management for coastal marine aquaculture (WGSC-SHoCMed) http://gfcmsitestorage.blob.core.windows.net/documents/web/CAQ/WGSC/2013/SHoCMed-Training/InformationNotetraining-workshop-AZAMorocco2013.pdf

FAOLEX. 2019a. FAO Fisheries and Aquaculture Database, part of the wider FAOLEX database of national legislation, policies and bilateral agreements on food, agriculture and natural resources management
http://www.fao.org/faolex/collections/en/?search=adv&subj_coll=Fisheries

FAOLEX. 2019b. FAO Fisheries and Aquaculture Database, part of the wider FAOLEX database of national legislation, policies and bilateral agreements on food, agriculture and natural resources management
http://www.fao.org/faolex/country-profiles/general-profile/en/?iso3=EGY

FAOLEX. 2019c. FAO Fisheries and Aquaculture Database, part of the wider FAOLEX database of national legislation, policies and bilateral agreements on food, agriculture and natural resources management – TURKISH Law No. 5491 amending the Environmental Law No. 2872
http://www.fao.org/faolex/results/details/en/c/LEX-FAOC065097

FEAP. 2017. European Aquaculture Production Report 2008-2016
http://feap.info/index.php/data/

FFE. 2018. Fish Farming Expert: Fish Farming School – Rodrigo Orrego, published 19.06.2015 15:00 (Updated 24.02.2018 12:23)
https://www.fishfarmingexpert.com/article/fishfarming-school/

FFE. 2017. Fish Farming Expert: Injectable vaccine for seabass diseases unveiled, Published 16.06.2017 00:01 (Updated 24.02.2018 14:23)
https://www.fishfarmingexpert.com/article/injectable-vaccine-for-sea-bass-diseases-unveiled/

FFUS. 2015. French Food in the US: The Fish Farming Sector in France. May 6, 2015.
http://frenchfoodintheus.org/805

FGM. 2017. Federation of Greek Maricultures - Aquacuture in Greece 2017
https://www.fgm.com.gr/uploads/file/FGM17_WEB_ENG.PDF

FGM. 2016. Federation of Greek Maricultures - Aquacuture in Greece 2016
https://www.fgm.com.gr/uploads/file/FGM_ENG_2016.pdf

FORCE. 2013. Fisheries and Aquaculture-Oriented Research Capacity in Egypt project: FORCE Final Publishable Summary 1 November 2011– 30 April 2014
https://cordis.europa.eu/docs/results/295/295004/final1-force-final-publishable-summary-submit-.pdf

Fadel A, Mabrok M, Aly S. 2018. Epizootics of Pseudomonas anguilliseptica among cultured seabream (Sparus aurata) populations: Control and treatment strategies. Microbial Pathogenesis. 121. 10.1016/j.micpath.2018.04.021.

https://www.researchgate.net/publication/324559050_Epizootics_of_Pseudomonas_anguilliseptica_among_cultured_seabream_Sparus_aurata_populations_Control_and_treatment_strategies

Feidi, I. 2018. Will the New Large-Scale Aquaculture Projects Make Egypt Self Sufficient in Fish Supplies? MedFAR., 1(1):31-41.
http://dergipark.gov.tr/download/article-file/410652

Ferreira, C.S., Nunes, B.A., Henriques-Almeida, J.M., Guilhermino, L. 2007. Acute toxicity of oxytetracycline and florfenicol to the microalgae Tetraselmis chuii and to the crustacean Artemia parthenogenetica. Ecotoxicol. Environ. Saf. 67, 452–458.

Fezzardi D, Massa F, Àvila-Zaragoza P, Rad F, Yücel-Gier G, Deniz H, Hadj Ali Salem M, Hamza HA, Ben Salem S. 2013. Indicators for sustainable aquaculture in Mediterranean and Black Sea countries. Guide for the use of indicators to monitor sustainable development of aquaculture. *Studies and Reviews. General Fisheries Commission for the Mediterranean*. No. 93. Rome, FAO. 2013. 60 pp.
http://www.fao.org/docrep/017/i3194e/i3194e.pdf

Firminoa J, Furonesa MD, Andreea KB, Sarasquetec C, Ortiz-Delgadoc JB, Asencio-Alcudiad G, Gisberta E. 2019. Contrasting outcomes of Vibrio harveyi pathogenicity in gilthead seabream, Sparus aurata and European seabass, Dicentrachus labrax - in Aquaculture Volume 511, 15 September 2019, 734210
https://www.sciencedirect.com/science/article/abs/pii/S0044848619303953?via%3Dihub

Fishar MR. 2006. Red swamp crayfish (Procambarus clarkii) in River Nile, Egypt: Case study. Biodiversity Monitoring and Assessment Project (BioMap), Nature Conservation Sector, Egyptian Environmental Affairs Agency, Ministry of State for Environmental Affairs, pp: 32.
https://pdfs.semanticscholar.org/6d42/61c0fb6f11da71b4f8238a28a7889205e2e3.pdf

Fishbase. 2018a. Summary: European Seabass – *Dicentrarchus labrax*
https://www.fishbase.de/summary/dicentrarchus-labrax.html

Fishbase. 2018b. Summary: Gilthead Seabream – *Sparus aurata*
https://www.fishbase.de/summary/Sparus-aurata.html

Fishbase. 2018c. Summary: Meagre – *Argyrosomus regius*
https://www.fishbase.de/summary/Argyrosomus-regius.html

Fisheries and Oceans Canada. 2003. A Scientific Review of the Potential Environmental Effects of Aquaculture in Aquatic Ecosystems. Far-field environmental effects of marine finfish aquaculture (Hargrave, B.T.); ecosystem level effects of marine bivalve aquaculture (Cranford, P., Dowd, M., Grant, J., Hargrave, B., McGladdery, S.); chemical use in marine finfish aquaculture in Canada: a review of current practices and possible environmental effects (Burridge, L.E.). Canadian Technical Report of Fisheries and Aquatic Sciences 2450 vol. 1 (131 pp.).

FishMedPlus. 2019. FishMedPlus Coalition Newsletter February 2019 (including link to new listing is of all fish medicines including vaccines approved in the European Union) https://www.fve.org/cms/wp-content/uploads/FishMedPlus-Newsletter-February-2019.pdf

FishMedPlus. 2018. FishMedPlus Coalition Newsletter February 2018 https://www.fve.org/cms/wp-content/uploads/NewsletterFishMedPlusFeb2018.pdf

Fodelianakis S, Papageorgiou N, Karakassis I, Ladoukakis ED. 2015. Community structure changes in sediment bacterial communities along an organic enrichment gradient associated with fish farming. Annals of Microbiology. 65. 331-338. 10.1007/s13213-014-0865-4. https://www.researchgate.net/publication/261595499Communitystructurechangesinsediment bacterialcommunitiesalonganorganicenrichmentgradientassociatedwithfishfarming

FranceAgriMer. 2017. The Fisheries and Aquaculture Sector in France. http://www.franceagrimer.fr/content/download/50905/489273/file/CC%20pêcheanglaisV6.pdf

Freyhof J, Kottelat M. 2008. *Dicentrarchus labrax*. The IUCN Red List of Threatened Species 2008: e.T135606A4159287. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T135606A4159287.en. Downloaded on 24 September 2018.

GAA. 2014. Global Aquaculture Advocate: The search for sustainable grouper farming - Vaccines, virus-free hatchery support greater production. Friday, 3 January 2014 Huey-Lang Yang, Ph.D. Han-You Lin, Ph.D. Chi-Chu Lin https://www.aquaculturealliance.org/advocate/search-for-sustainable-grouper-farming/

GAFRD. 2018a. Egyptian General Authority for Fish Resources Development - Ministry of Agriculture and Land Reclamation https://www.gafrd.org

GAFRD. 2018b. General Authority for Fish Resources Development: 2018 Fish Statistics Year Book

GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). 1997. Towards safe and effective use of chemicals in coastal aquaculture. Reports and Studies No. 65. FAO, Rome (40 pp.).

GFCM. 2018a. General Fisheries Commission for the Mediterranean - Strategy for the sustainable development of Mediterranean and Black Sea aquaculture. FAO Rome, 2018 http://www.fao.org/3/I9766EN/i9766en.pdf

GFCM. 2018b. General Fisheries Commission for the Mediterranean - Workshop on animal health and risk analysis in finfish aquaculture. Larnaca, Cyprus, 3–4 October 2018
http://www.fao.org/gfcm/reports/technical-meetings/detail/en/c/1234289/

GFCM. 2017a. Resolution GFCM/41/2017/1 on a strategy for the sustainable development of Mediterranean and Black Sea aquaculture
http://www.fao.org/gfcm/decisions/en/

GFCM. 2017b. Guidelines on a harmonized environmental monitoring programme (EMP) for marine finfish cage farming in the Mediterranean and the Black Sea (updated version May 2017). Document presented at the tenth session of the Scientific Advisory Committee on Aquaculture (Izmir, Turkey, 27–29 March 2017) as Appendix 2 of document GFCM:CAQ10/2017/Inf.14 (unpublished).
https://gfcm.sharepoint.com/AQ/SHoCMed%204/3.2%20Survey%20EMP/EMP_updated%20version%20May%202017.pdf

GFCM. 2012. Resolution GFCM/36/2012/1 on guidelines on allocated zones for aquaculture (AZA)
https://gfcmsitestorage.blob.core.windows.net/documents/Decisions/GFCM-Decision--RES-GFCM_36_2012_1-en.pdf

GMFSA. 2019. Galaxidi Marine Farm S.A.
http://www.gmf-sa.gr/50_HomeEn.htm

GLOBEFISH. 2019. GLOBEFISH - Information and Analysis on World Fish Trade – FAO 11/04/2019
http://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/1189941/

GLOBEFISH. 2017. FAO GLOBEFISH - Proactive action pays off for seabass and seabream sector – FAO 12/12/2017
http://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/1072507/

GLOBEFISH. 2018. FAO Seabass and Seabream Market Reports
http://www.fao.org/in-action/globefish/market-reports/seabass-and-seabream/en/

García BG, Jiménez CR, Aguado-Giménez F, García JG. 2016. Life Cycle Assessment of Gilthead Seabream (*Sparus aurata)* Production in Offshore Fish Farms - Sustainability 2016, 8, 1228; doi:10.3390/su8121228
http://www.mdpi.com/2071-1050/8/12/1228

Gausen M et al. 2014. Aeration as a potential attempt to improve Mediterranean aquaculture. Aquaculture Magazine, December 2014 – January 2015
http://www.hydroson.com/wp-content/uploads/2015/01/6-11-Mediterranean-Aquaculture-AQM40-6.pdf

Genimpact. 2005. EU funded project to evaluation the genetic impact of aquaculture activities on native populations
https://www.imr.no/genimpact/en

Ghanem A, Haggag M. 2015. Assessment of the Feasibility of Using Filter Made of Rice Straw for Treating Aquaculture Effluents in Egypt, Resources and Environment 2015, 5(5): 135-145 DOI: 10.5923/j.re.20150505.01
http://article.sapub.org/10.5923.j.re.20150505.01.html

Gkagkavouzis K, Karaiskou N, Katopodi T, Leonardos I, Abatzopoulos T, Triantafyllidis A. 2019. The genetic population structure and temporal genetic stability of gilthead sea bream Sparus aurata populations in the Aegean and Ionian Seas, using microsatellite DNA markers. Journal of Fish Biology. 94. 10.1111/jfb.13932.
https://onlinelibrary.wiley.com/doi/abs/10.1111/jfb.13932

González-Renteria M, Bustamante-González JD, Dosta MCM. 2016. Risks of pharmaceutical chemicals used in aquaculture: alternatives and current perspective – 284 Scientific Journal of Animal Science (2016) 5(4) 284-296
ISSN 2322-1704 doi: 10.14196/sjas.v5i4.2205
https://www.reearchgate.net/publication/306080321_Risks_of_pharmaceutical_chemicals_used_in_aquaculture_alternatives_and_current_perspective

Gonzalez-Silvera D, Izquierdo-Gomez D, Fernandez-Gonzalez V, Martínez-López FJ, López-Jiménez JA, Sanchez-Jerez P. 2015. Mediterranean fouling communities assimilate the organic matter derived from coastal fish farms as a new trophic resource - Marine Pollution Bulletin 91 (2015) 45–53
https://www.researchgate.net/requests/r42231278

Google Maps. 2019. Imagery @2019 Maxar Technologies, TerraMetrics, Map data @2019 ORION-ME
https://www.google.com/maps/place/Damietta,+Qism+Damietta,+Damietta,+Damietta+Governorate,+Egypt/@31.5146162,31.8642952,2815m/data=!3m1!1e3!4m5!3m4!1s0x14f9e55ffce10e15:0x99ae0f78405c14d2!8m2!3d31.4175388!4d31.8144434

Google Maps. 2018. Imagery @2018 Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Landsat / Copernicus, IBCAO, Map data @2018 Google, ORION-ME
https://www.google.co.uk/maps/@37.4757164,17.0867212,1696860m/data=!3m1!1e3?hl=en

Goulding I & Kamel M. 2013. Institutional, Policy and Regulatory Framework for Sustainable Development of the Egyptian Aquaculture Sector - Project Report: 2013-39
http://aquaticcommons.org/12756/1/WF-2013-39.pdf

Grigorakia K, Rigos G. 2011. Aquaculture effects on environmental and public welfare – The case of Mediterranean mariculture – Chemosphere https://www.researchgate.net/search.Search.html?type=publication&query=Aquaculture%20effects%20on%20environmental%20and%20public%20welfare%20–%20The%20case%20of%20Mediterranean%20mariculture

Guardian. 2017. Guardian Newspaper - Alexandria: locals adapt to floods as coastal waters inch closer – 19 January 2017
https://www.theguardian.com/environment/2017/jan/19/alexandria-egypt-locals-adapt-storms-floods-coastal-waters-rise

Guardiola FA, Cuesta A, Meseguer J, Esteban MA. 2012. Risks of using antifouling biocides in aquaculture. Int. J. Mol. Sci. 13, 1541–1560.
http://www.mdpi.com/1422-0067/13/2/1541

Haffray P, Mahla R, Ould Taleb Sidi M, Prista N, Hassan M, Castelnaud G, Karahan-Nomm B, Gamsiz K, Sadek S, Bruant JS, Balma P, Bonhomme F. 2012. Very high genetic fragmentation in a large marine fish, the meagre *Argyrosomus regius* (Sciaenidae, Perciformes): Impact of reproductive migration, oceanographic barriers and ecological factors. Aquatic Living Resources. 25. 173-183. 10.1051/alr-journal.org.
https://www.researchgate.net/publication/235673532_Very_high_genetic_fragmentation_in_a_large_marine_fish_the_meagre_Argyrosomus_regius_Sciaenidae_Perciformes_Impact_of_reproductive_migration_oceanographic_barriers_and_ecological_factors

Harache Y, Paquotte P. 1996. The Development of Marine Fish Farming in Europe: A Parallel with Salmon Culture – European Aquaculture Society - Seabass and Seabream Workshop Verona - October 16-18, 1996
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.596.1527&rep=rep1&type=pdf

Haya, K., Burridge, L.E., Davies, I.M., Ervik, A. 2005. A review and assessment of environmental risk of chemicals used for the treatment of sea lice infestations of cultured salmon. Handb. Environ. Chem. 5, 305–340.

Hebisha H & Fathi M. 2014. *Small and medium scale aquaculture value chain development in Egypt: Situation analysis and trends.* WorldFish/ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute (ILRI).
https://cgspace.cgiar.org/bitstream/handle/10568/41882/PR_SituationAnalysis_Egypt_web.pdf

Hilmi N, Allemand D, Kavanagh C, Laffoley D, Metian M, Osborn D, Reynaud S. 2015. *Bridging the Gap Between Ocean Acidification Impacts and Economic Valuation: Regional Impacts of Ocean Acidifcation on Fisheries and Aquaculture.* Gland, Switzerland: IUCN. 136 pages
https://portals.iucn.org/library/sites/library/files/documents/2015-011.pdf

Hofherr J, Natale F, Trujillo P. 2015. Is lack of space a limiting factor for the development of aquaculture in EU coastal areas? Ocean & Coastal Management 116:27-36 https://reader.elsevier.com/reader/sd/pii/S0964569115001635?token=F7177B0B0D0B97107EDCADEC46B3722DE3A39392331D1E5F4B785C6D5A01299C5B7278BF8CC0C2B7399C0E8AC2652C4C

Holmer M. 2010. Environmental issues of fish farming in offshore waters: perspectives, concerns and research needs - Aquacult Environ Interact 1: 57–70, 2010 http://www.int-res.com/articles/aei2010/1/q001p057.pdf

Holmer M, Argyrou M, Dalsgaard T, Danovaro R, Diaz-Almela E, Duarte CM, Frederiksen M, Grau A, Karakassis I, Marba N, Mirto S, Perez M, Pusceddu A, Tsapakis M. 2008. Effects of fish farm waste on Posidonia oceanica meadows: Synthesis and provision of monitoring and management tools. Mar. Pollut. Bull., 56:1618–1629. https://www.academia.edu/20348692/EffectsoffishfarmwasteonPosidoniaoceanicameadowsSynthesisandprovisionofmonitoringandmanagementtools?auto=download

Huntington TC, Roberts H, Cousins N, Pitta V, Marchesi N, Sanmamed A, Hunter-Rowe T, Fernandes TF, Tett P, McCue J, Brockie N. 2006. Some aspects of the environmental impact of aquaculture in sensitive areas. Final Report to the Directorate-General Fish and Maritime Affairs of the European Commission, Poseidon Aquatic Resource Management Ltd., U.K. https://ec.europa.eu/fisheries/sites/fisheries/files/docs/publications/aquaculture_environment_2006_en.pdf

Hyder K, Radford Z, Prellezo R, Weltersbach MS, Lewin WC, Zarauz L, Ferter K, Ruiz J, Townhill B, Mugerza E, Strehlow HV. 2017. Research for PECH Committee - Marine recreational and semi-subsistence fishing - its value and its impact on fish stocks, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels http://www.europarl.europa.eu/RegData/etudes/STUD/2017/601996/IPOL_STU(2017)601996_EN.pdf

ICES. 2012. Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO), 31 January – 04 February 2012, Lisbon, Portugal. ICES CM 2012/SSGHIE:03. 68 pp. http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGHIE/2012/WGPDMO12.pdf

IDRC. 2012. International Development Research Centre: Adaptation to the Impacts of Sea Level Rise in the Nile Delta Coastal Zone (Egypt) – final project report https://www.idrc.ca/en/project/adaptation-impacts-sea-level-rise-nile-delta-coastal-zone-egypt

IGFA. 2018. The International Game Fish Association World Records Database http://wrec.igfa.org/WRecSearchList.aspx?lc=AllTackle

IOA. 2018. Institute of Aquaculture, University of Stirling: May 2018 Special Edition of Fish Farmer Magazine – Meagre Mystery, Unravelling systemic granulomatous disease in Mediterranean farms
https://issuu.com/fishfarmermagazine/docs/ioa_-_special

IUCN. 2015. International Union for Conservation of Nature: *Argyrosomus regius*. The IUCN Red List of Threatened Species 2015:
e.T198706A49227019. http://dx.doi.org/10.2305/IUCN.UK.2015-
https://www.iucnredlist.org/species/198706/49227019

IUCN. 2009. Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management, IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pages.
https://portals.iucn.org/library/sites/library/files/documents/2009-032.pdf

IUCN. 2007. Guide for the Sustainable Development of Mediterranean Aquaculture. Interaction between Aquaculture and the Environment. IUCN, Gland, Switzerland and Malaga, Spain. 107 pages.
https://portals.iucn.org/library/sites/library/files/documents/2007-008.pdf

IUCN. 2008. International Union for Conservation of Nature: *Dicentrarchus labrax*. The IUCN Red List of Threatened Species. IUCN 2008
https://www.iucnredlist.org/species/135606/4159287

International Aquafeed. 2016. Aqua feeds in the seabream farming industry – by Diogo Thomaz, Stella Adamidou, Dr Florian Nagel, Dr Hanno Slawski – Aller Aqua Group – A brief history of seabream nutrition – International Aquafeed, July-August 2016
https://issuu.com/international_aquafeed/docs/iaf1604_w1/40

Intrafish. 2019. Greek seabass, bream merger an act of 'survival' – by Rachel Mutter May 7th, 2019
https://www.intrafish.com/aquaculture/1774378/greek-seabass-bream-merger-an-act-of-survival?utm_source=IntraFish+Aquaculture+Newsletter&utm_campaign=b4e97327e9-EMAIL_CAMPAIGN_2019_05_08_11_00&utm_medium=email&utm_term=0_ec4b681694-b4e97327e9-245248853

Izquierdo-Gomez D, Arechavala-Lopez P, Bayle-Sempere JT, Sanchez-Jerez P. 2017. Assessing the influence of gilthead sea bream escapees in landings of Mediterranean fisheries through a scale-based methodology. Fish. Manage.Ecol., 24(1): 62–72 (2017).
https://www.researchgate.net/publication/312661834_Assessing_the_influence_of_gilthead_sea_bream_escapees_in_landings_of_Mediterranean_fisheries_through_a_scale-based_methodology

Izquierdo-Gómez, D, et al. 2016. Modeling population dynamics and small-scale fisheries yields of fish farming escapes in Mediterranean coastal areas. Ecological Modelling (2016) https://www.researchgate.net/publication/295100751Modelingpopulationdynamicsandsmall-scalefisheriesyieldsoffishfarmingescapesinMediterraneancoastalareas

Izquierdo-Gómez D, Sánchez-Jerez P, Fernández-Jover D, Toledo-Guedes K, Arechavala-Lopez P, Forcada-Almarcha A, Valle-Pérez C. 2014a. Good practice guide for the management of escapes in marine aquaculture: Vol I. Prevention. ESCA-FEP project, European Fisheries Fund. Oceanographic Ed. 44 pp.
Legal deposit: GC 1192-2014
https://www.researchgate.net/publication/273949333_Guia_de_buenas_practicas_para_la_gestion_de_escapes_en_la_acuicultura_marina_Vol_I_Prevencion

Izquierdo-Gómez D, Sánchez-Jerez P, Fernández-Jover D, Toledo-Guedes K, Arechavala-Lopez P, Forcada-Almarcha A, Valle-Pérez C. 2014b. Guidance good practices for the management of escapes in marine aquaculture: Vol II. Mitigation. ESCA-FEP project, European Fisheries Fund. Oceanographic Ed. 32 pp.
Legal deposit: GC 19-2015 ISBN-13: 978-84-606-5522-0
https://www.researchgate.net/publication/273949247_Guia_de_buenas_practicas_para_la_gestion_de_escapes_en_la_acuicultura_marina_Vol_II_Mitigacion

Jackson D, Drumm A, McEvoy S, Jensen Ø, Mendiola D, Gabiña G, Borg JA, Papageorgiou N, Karakassis Y, Black KD. 2015. A pan-European valuation of the extent, causes and cost of escape events from sea cage fish farming - Aquaculture 436 (2015) 21–26
https://www.sciencedirect.com/science/article/pii/S0044848614005481

Janssen K, Chavanne H, Berentsen P, Komen H. 2016. Impact of selective breeding on European aquaculture. Aquaculture. 10.1016/j.aquaculture.2016.03.012
https://www.researchgate.net/publication/297678584_Impact_of_selective_breeding_on_European_aquaculture

Janssen K, Berentsen P, Besson M, Komen H. 2017. Derivation of economic values for production traits in aquaculture species - Janssen *et al. Genetic Selection Evolution (2017) 49:5*
DOI 10.1186/s12711-016-0278-x
https://link.springer.com/content/pdf/10.1186%2Fs12711-016-0278-x.pdf

Kalantzi I, Mylona K, Rico A, Pergantis SA, Tsapakis M. 2019. Effect of aquaculture on sediment in Greece: metals and antibiotics - HellenicCenter Marine Research presented in the 17th Congress of Ichthyologist at Heralkleion, Crete, 31Oct-3 Nov 2019 (http://psid.bio.auth.gr/)

Karakassis I. 2013. Environmental interactions and initiatives on site selection and carrying capacity estimation for fish farming in the Mediterranean. *In* L.G. Ross, T.C. Telfer, L. Falconer, D. Soto & J. Aguilar-Manjarrez, eds. *Site selection and carrying capacities for inland and coastal aquaculture,* pp. 161–170. FAO/Institute of Aquaculture, University of Stirling, Expert

Workshop, 6–8 December 2010. Stirling, the United Kingdom of Great Britain and Northern Ireland. FAO Fisheries and Aquaculture Proceedings No. 21. Rome, FAO. 282 pp. http://www.fao.org/tempref/FI/CDrom/P21/root/09.pdf

Karakassis I, Papageorgiou N, Kalantzi I, Sevastou K, Koutsikopoulos C. 2013. Adaptation of fish farming production to the environmental characteristics of the receiving marine ecosystems: A proxy to carrying capacity. Aquaculture. 408-409. 184–190. 10.1016/j.aquaculture.2013.06.002 https://www.researchgate.net/publication/256460569_Adaptation_of_fish_farming_production_to_the_environmental_characteristics_of_the_receiving_marine_ecosystems_A_proxy_to_carrying_capacity

Karakassis I, Hatziyanni E, Tsapakis M, Plaiti W. 1999. Benthic recovery following cessation of fish farming: a series of successes and catastrophes. Marine Ecology-Progress Series 184, 205-218 https://www.researchgate.net/publication/222092754Benthicrecoveryfollowingcessationoffishfarming Aseriesofsuccessesandcatastrophes

Karamanlidis A, Dendrinos P. 2015. *Monachus monachus* (errata version published in 2017). *The IUCN Red List of Threatened Species* 2015: e.T13653A117647375. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T13653A45227543.en. Downloaded on 26 June 2019. https://www.iucnredlist.org/species/13653/117647375

Karamanlidis A, Androukaki E, Adamantopoulou S, Chatzispyrou A, Johnson WM, Kotomatas S, Papadopoulos A, Paravas V, Paximadis G, Pires R, Tounta E, Dendrinos P. 2008. Assessing accidental entanglement as a threat to the Mediterranean monk seal *Monachus monachus*. *Endangered Species Research*, *5*(2-3), 205-213. https://www.researchgate.net/publication/250221653_Assessing_accidental_entanglement_as_a_threat_to_the_Mediterranean_monk_seal_Monachus_monachus

Khalifa E, Khallaf M, Hashem M. 2016. Molecular Study on some Virulence and Fluoroquinolone Resistance Genes of *Pseudomonas aeruginosa* Isolated from Naturally Infected Cultured Sea Bream Fish (*Sparus aurata*) in Egypt. J Infect Dis Preve Med 4: 136. doi: 10.4172/2329-8731.1000136 https://www.researchgate.net/profile/Eman_Khalifa4/publication/311445007_Molecular_Study_on_some_Virulence_and_Fluoroquinolone_Resistance_Genes_of_Pseudomonas_aeruginosa_Isolated_from_Naturally_Infected_Cultured_Sea_Bream_Fish_Sparus_aurata_in_Egypt/links/584e918208aeb989252c1729/Molecular-Study-on-some-Virulence-and-Fluoroquinolone-Resistance-Genes-of-Pseudomonas-aeruginosa-Isolated-from-Naturally-Infected-Cultured-Sea-Bream-Fish-Sparus-aurata-in-Egypt.pdf

Khalil R, Medhat SS, Hanan AG, Khallaf M, Sherif ES. 2018. Seasonal Parasitic Infestations and their Close Relationship to Immune Suppression in Cultured Seabass (*Dicentrarchus labrax l*)

and Sea Bream (*Sparus auratus*). Biomed J Sci&Tech Res 6(4)- 2018. BJSTR. MS.ID.001376. DOI: 10.26717/ BJSTR.2018.06.001376.
https://biomedres.us/pdfs/BJSTR.MS.ID.001376.pdf

Khalil RH, Saad TT, El-Hamid TMA. 2014. Some Studies on Parasitic Infestations in Some Marine Water Fish with Special Reference on Isopoda -JOURNAL OF THE ARABIAN AQUACULTURE SOCIETY Vol. 9 No. 1 Arabian Aquaculture Conference
https://www.researchgate.net/publication/274014877_Some_Studies_on_Parasitic_Infestations_in_Some_Marine_Water_Fish_with_Special_Reference_on_Isopoda

Khalil MT, Shaltout KH. 2006. Lake Bardawil; Zaranik Protected Area. Publication of National Biodiversity Unit, No. 15, Egyptian Environmental Affairs Agency, Egypt, 580 pp..
https://www.researchgate.net/publication/275968865_Khalil_M_T_and_Shaltout_K_H_2006_Lake_Bardawil_Zaranik_Protected_Area_Publication_of_National_Biodiversity_Unit_No_15_Egyptian_Environmental_Affairs_Agency_Egypt_580_pp

Kıraç C, Savaş Y, Güçlüsoy H. 2004. 40 Years of Monk Seal Conservation in Turkey. The Monachus Guardian. 7.
https://www.researchgate.net/publication/301636356_40_Years_of_Monk_Seal_Conservation_in_Turkey

Kletou D, Kleitou P, Savva I, Attrill M, Antoniou C. 2018. Seagrass recovery after fish farm relocation in the eastern Mediterranean. Marine Environmental Research. 140. 10.1016/j.marenvres.2018.06.007.
https://www.researchgate.net/publication/325738109_Seagrass_recovery_after_fish_farm_relocation_in_the_eastern_Mediterranean

Korun J, İnce AG, Karaca M. 2013. Antibiotic Resistance and Plasmid Profile Of Vibrio Alginolyticus Strains Isolated From Cultured European Seabass (*Dicentrarchus Labrax*, L.) - Bull Vet Inst Pulawy 57, 173-177, 2013 - Doi: 10.2478/Bvip-2013-0032
https://www.degruyter.com/downloadpdf/j/bvip.2013.57.issue-2/bvip-2013-0032/bvip-2013-0032.pdf

Kružić N, Mustać B, Župan I, Čolak S. 2016. MEAGRE (Argyrosomus regius Asso, 1801) AQUACULTURE IN CROATIA. Croatian Journal of Fisheries, 2016, 14-19
https://hrcak.srce.hr/file/227951

Laganà P, Caruso G, Minutoli E, Zaccone R, Delia S. 2011. Susceptibility to antibiotics of Vibrio spp. and Photobacterium damsela ssp. piscicida strains isolated from Italian aquaculture farms - NEW MICROBIOLOGICA, 34, 53-63, 2011
https://www.researchgate.net/publication/49857699_Susceptibility_to_antibiotics_of_Vibrio_spp_and_Photobacterium_damsela_ssp_piscicida_strains_isolated_from_Italian_aquaculture_farms

Lai, H.T., Hou, J.H., Su, C.I., Chen, C.L. 2009. Effects of chloramphenicol, florfenicol, and thiamphenicol on growth of algae Chlorella pyrenoidosa, Isochrysis galbana, and Tetraselmis chuii. Ecotoxicol. Environ. Saf. 72, 329–334.

Lalumera, G.M., Calamari, D., Galli, P., Castiglioni, S., Crosa, G., Fanelli, R. 2004. Preliminary investigation on the environmental occurrence and effects of antibiotics used in aquaculture in Italy. Chemosphere 54, 661–668.

Lopez-Jimena B, Cherif N, Garcia-Rosado E, Infante C, Cano I, et al. 2010. A combined RT-PCR and dot-blot hybridization method reveals the coexistence of SJNNV and RGNNV betanodavirus genotypes in wild meagre (Argyrosomus regius). J Appl Microbiol 109: 1361-1369. https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1365-2672.2010.04759.x

Lulijwa R, Rupia EJ, Alfaro AC. 2019. Antibiotic use in aquaculture, policies and regulation, health and environmental risks: a review of the top 15 major producers - First published: 07 April 2019 - Rev Aquacult. doi:10.1111/raq.12344
https://onlinelibrary.wiley.com/doi/abs/10.1111/raq.12344

Luten JB et al. 2006. Seafood Research from Fish to Dish: Quality, Safety and Processing of Wild and Farmed Fish. Wageningen Academic Publishers
https://books.google.co.uk/books?id=OeeTZD13yA4C&pg=PA472&lpg=PA472&dq=proximate+analysis+showing+protein+content+of+a+whole+farmed+meagre&source=bl&ots=asLb1R6h2M&sig=yssxXQtSL9I4Tz0lngT-WmL1EOs&hl=en&sa=X&ved=0ahUKEwjQ2MSsja7cAhUBDMAKHZVoA1IQ6AEIZzAQ#v=onepage&q=proximate%20analysis%20showing%20protein%20content%20of%20a%20whole%20farmed%20meagre&f=false

MADE. 2013. Marine Aquaculture Development in Egypt Italian Egyptian Debt SWAP Program: The Road Map - June 2013
https://www.feedingknowledge.net/home?p_p_id=1_WAR_feeding_knowledgeportlet&p_p_lifecycle=2&p_p_state=pop_up&p_p_mode=view&p_p_cacheability=cacheLevelPage&_1_WAR_feeding_knowledgeportlet_cmd=serveAttachment&_1_WAR_feeding_knowledgeportlet_stepAttachmentId=6983

MBA. 2016. Monterey Bay Aquarium Seafood Watch Standard for Aquaculture: Aquaculture Standard Version A3.1 (Jan. 2016-Sept. 2016)
http://www.seafoodwatch.org/-/m/sfw/pdf/criteria/aquaculture/mba_seafood%20watch_aquaculture%20standard_version%20a3.1.pdf?la=en

MEE. 2015. Ministry for Environment and Energy. Special Framework for the Aquaculture – Greece – Seminar 'Good Practices in administrative simplification for the promotion of sustainable aquaculture, Brussels, November 2015 https://ec.europa.eu/fisheries/sites/fisheries/files/docs/pages/spatial-planning-for-aquaculture-el.pdf

Macfadyen G. et al. 2011. Value-chain analysis of Egyptian aquaculture. Project report 2011- 54. The WorldFish Center. Penang, Malaysia. 84 pp.
http://pubs.iclarm.net/resourcecentre/WF3168.pdf

Mahmoud NE, Mahmoud AM, Fahmy MM. 2014. Parasitological and Comparative Pathological Studies on Monogenean Infestation of Cultured Sea Bream (*Sparus aurata*, Spariidae) in Egypt. Oceanography 2: 129. doi: 10.4172/2332-2632.1000129
https://www.omicsonline.org/open-access/parasitological-and-comparative-pathological-studies-on-monogenean-infestation-of-cultured-sea-bream-sparus-aurata-spariidae-in-egypt-2332-2632-2-129.pdf

Maricchiolo G, Mirto S, Caruso G, Caruso T, Bonaventura R, Celi M, Matranga V, Genovese L. 2011. Welfare status of cage farmed European seabass (Dicentrarchus labrax): A comparison between submerged and surface cages. Aquaculture 314 (2011) 173–181.
https://www.researchgate.net/publication/216437627WelfarestatusofcagefarmedEuropeanseabassDicentrarchuslabraxacomparisonbetweensubmergedandsurfacecages

Marine Institute for SWRBD. 2007. Veterinary treatments and other substances used in finfish aquaculture in Ireland. Report of March 2007 (31 pp.).

Masria A, Negm A, Iskander M, Saavedra O. 2014. Coastal zone issues: a case study (Egypt) - Procedia Engineering 70 (2014) 1102 – 1111
https://ac.els-cdn.com/S1877705814001246/1-s2.0-S1877705814001246-main.pdf?tid=2f0a0a3d-cd0e-4051-8256-e9422f4d1dd5&acdnat=152527098231fb84c9c0c10e92f914da2a0d788ce8

Massa F, Onofri L, Fezzardi D. 2017. Aquaculture in the Mediterranean and the Black Sea: a Blue Growth perspective
https://www.researchgate.net/publication/313359435AquacultureintheMediterraneanandtheBlackSeaaBlueGrowthperspective

Mateus AP, Costa R, Gisbert E, Pinto PIS, Andree KB, Estévez A, Power DM. 2017. Thermal imprinting modifies bone homeostasis in cold-challenged sea bream (Sparus aurata) - Journal of Experimental Biology 2017 220: 3442-3454; doi: 10.1242/jeb.156174
https://jeb.biologists.org/content/220/19/3442

Mayor DG, NB Gray, GSI Hattich, Thornton B. 2017. Detecting the presence of fish farm-derived organic matter at the seafloor using stable isotope analysis of phospholipid fatty acids. Scientific Reports. 7. 10.1038/s41598-017-05252-w.

https://www.researchgate.net/publication/318360794_Detecting_the_presence_of_fish_farm-derived_organic_matter_at_the_seafloor_using_stable_isotope_analysis_of_phospholipid_fatty_acids

MedAID. 2018. Health forum discussion on Viral Encephalopathy and Retinopathy : 17-28 September 2018
http://www.medaid-h2020.eu/index.php/2018/09/10/health-forum-discussion-on-viral-encephalopathy-and-retinopathy/

Megahed ME, Ghoneim S, Desouky G, EL-Dakar A. 2013. Major constraints facing development of marine shrimp farming in Egypt. J. Arabian Aquaculture Soc., 8(2): 321–330 (2013)
http://www.arabaqs.org/journal/vol_8/2/Text%2013-29.pdf

Méndez N. 2006. Effects of teflubenzuron on sediment processing by members of the Capitella species-complex. Environ. Pollut. 139, 118–124.

Miccoli A, Saraceni PR, Scapigliati G. 2019. Vaccines and immune protection of principal Mediterranean marine fish species, Fish and Shellfish Immunology (2019), doi: https://doi.org/10.1016/j.fsi.2019.09.065.
https://www.researchgate.net/publication/336148636_Vaccines_and_immune_protection_of_principal_Mediterranean_marine_fish_species

Miralles L, Mrugala A, Sanchez-Jerez P, Juanes F, Garcia-Vazquez E. 2016. Potential Impact of Mediterranean Aquaculture on the Wild Predatory Bluefish, Marine and Coastal Fisheries, 8:1, 92-99
https://doi.org/10.1080/19425120.2015.1125977

Mirto S, Bianchelli S, Gambi C, Krzelj M, Pusceddu A, Scopa M, Holmer M, Danovaro R. 2010. Fish-farm impact on metazoan meiofauna in the Mediterranean Sea: Analysis of regional vs. habitat effects. Marine Environmental Research 69:38-47.
https://iris.unica.it/retrieve/handle/11584/123663/73638/064%20Mirto%20et%20al%20Mar%20Environ%20Res%202010.pdf

Mladineo I, Šegvić-Bubić T, Stanić R, Desdevises Y. 2013. Morphological Plasticity and Phylogeny in a Monogenean Parasite Transferring between Wild and Reared Fish Populations. PLOS ONE 8(4): e62011.
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0062011

Monfort MC. 2010. Present market situation and prospects of meagre (*Argyrosomus regius),* as an emerging species in Mediterranean aquaculture. *Studies and Reviews. General Fisheries Commission for the Mediterranean.* No. 89. Rome, FAO. 2010. 28p.
http://www.fao.org/docrep/013/i1675e/i1675e.pdf

Monfort, MC. 2007. Marketing of aquacultured seabass and seabream from the Mediterranean basin. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 82. Rome, FAO. 2007. 50
http://www.fao.org/docrep/010/a0968e/a0968e00.htm

Mongile F, Bonaldo A, Fontanillas R, Mariani L, Badiani A, Bonvini E, Parma L. 2014. Effects of dietary lipid level on growth and feed utilisation of gilthead seabream (Sparus aurata L.) at Mediterranean summer temperature - Italian Journal of Animal Science · May 2014
https://www.researchgate.net/publication/269110963_Effects_of_dietary_lipid_level_on_growth_and_feed_utilisation_of_gilthead_seabream_Sparus_aurata_L_at_Mediterranean_summer_temperature

Moreno P, Olveira JG, Labella A, Cutrin JM, Baro JC, Borrego JJ, Dopazo CP. 2014. Surveillance of Viruses in Wild Fish Populations in Areas around the Gulf of Cadiz (South Atlantic Iberian Peninsula). Applied and environmental microbiology. 80. 10.1128/AEM.02090-14.
https://www.researchgate.net/publication/264830675_Surveillance_of_Viruses_in_Wild_Fish_Populations_in_Areas_around_the_Gulf_of_Cadiz_South_Atlantic_Iberian_Peninsula

Moretti A, Pedini Fernandez-Criado M, Cittolin G, Guidastri R. 1999. Manual on hatchery production of seabass and gilthead seabream. Volume 1. Rome, FAO. 1999. 194 p.
http://www.fao.org/3/a-x3980e.pdf

Moustafa M, Eissa AE, Laila AM, Gaafar AY, Abumourad IMK, Elgendy MY. 2014. Mass Mortalities in Mari-Cultured European Seabass (Dicentrarchus labrax) at Northern Egypt - Research Journal of Pharmaceutical, Biological and Chemical Sciences - ISSN: 0975-8585
https://www.rjpbcs.com/pdf/2014_5(4)/[12].pdf

Moustafa M, Mohamed LA, Mahmoud MA, Soliman WS, El-Gendy MY. 2010. Bacterial infections affecting marine fishes in Egypt. J. Am. Sci., 6 (2010).
http://www.jofamericanscience.org/journals/am-sci/am0611/93_4002am0611_603_612.pdf

Mur R. 2014. Development of the aquaculture value chain in Egypt: Report of the National Innovation Platform Workshop, Cairo, 19-20 February 2014. Cairo: WorldFish
https://cgspace.cgiar.org/bitstream/handle/10568/35247/egypt_IPworlshop_feb2014.pdf?sequence=1&isAllowed=y

NBSAP. 2016. Egyptian National Biodiversity Strategy and Action Plan 2015 – 2030 – Arab Republic of Egypt Ministry of Environment, January 2016
http://extwprlegs1.fao.org/docs/pdf/egy156958.pdf

NOAA. 2019. National Marine Fisheries Service Fisheries Statistics and Economics Division – Commercial Fisheries Statistics - Annual Trade Data by Product, Country/Association
https://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/applications/annual-product-by-countryassociation

NOAA. 2018. National Oceanic and Atmospheric Administration - National Marine Fisheries Service Fisheries Statistics and Economics Division. Commercial Fisheries Statistics - Annual Trade Data by Product, Country/Association https://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/applications/annual-product-by-countryassociation

NORM/NORM-VET 2016. Usage of Antimicrobial Agents and Occurrence of Antimicrobial Resistance in Norway. Tromsø / Oslo 2017. ISSN:1502-2307 (print) / 1890-9965 (electronic) https://unn.no/Documents/Kompetansetjenester,%20-sentre%20og%20fagråd/NORM%20-%20Norsk%20overvåkingssystem%20for%20antibiotikaresistens%20hos%20mikrober/Rapporter/NORM%20NORM-VET%202016.pdf

NWRP. 2017. National Water Resources Plan – Arab Republic of Egypt Ministry of Water Resources and Irrigation: Water for the Future 2017 http://extwprlegs1.fao.org/docs/pdf/egy147082.pdf

Naciri M, Lemaire C, Borsa P, Bonhomme F. 1999. Genetic study of the Atlantic/Mediterranean transition in seabass (*Dicentrarchus labrax*), *Journal of Heredity*, Volume 90, Issue 6, 1 November 1999, Pages 591–596, https://doi.org/10.1093/jhered/90.6.591 https://academic.oup.com/jhered/article/90/6/591/2186903

Nada MA, Boura L, Grimanis K, Schofield G, El-Alwany MA, Noor N, Ommeran MM. 2013. Egypt's Barawil Lake: safe haven or deadly trap for sea turtles in the Mediterranean. A report by MEDASSET, Suez Canal University and Nature Conservation Egypt https://issuu.com/medasset/docs/bardawilegyptreport_final_2013

Nasopoulou C, Karantonis HC, Zabetakis I. 2011. Nutritional Value of Gilthead Sea Bream and Seabass - Dynamic Biochemistry, Process Biotechnology and Molecular Biology ©2011 Global Science Books http://www.globalsciencebooks.info/Online/GSBOnline/images/2011/DBPBMB_5(SI1)/DBPBMB_5(SI1)32-40o.pdf

Nasr-Alla A, Kenawy D, El-Naggar G, Beveridge M, Van der Heijden PGM. 2012. Evaluation of the use of freshwater by four Egyptian farms applying aquaculture – agriculture integration - Centre for Development Innovation, Wageningen University & Research Centre https://www.researchgate.net/publication/241872417_Evaluation_of_the_use_of_fresh_water_by_four_Egyptian_farms_applying_integrated_aquaculture_-_agriculture

Nathanailides C, Sophia Anastasiou S. 2015. Economic Efficiency of Filleting Yield of Farmed Mediterranean Marine Fish Species - VII International Conference "Water & Fish" - Conference Proceedings (p 134) https://arhiva.nara.ac.rs/bitstream/handle/123456789/842/30%20Water%20and%20Fish%202015%20-%20Nathanailides.pdf?sequence=1&isAllowed=y
http://www.cefah.agrif.bg.ac.rs/download/Water%20&%20Fish%202015.pdf

Nathanailides C, Kokokiris L, Karipoglou C, Kanlis G, Logothetis P, Mittakos I, Lenas D. 2013. Muscle Aerobic Capacity and Filleting Yield of Farmed Fish Species in the Mediterranean Sea - Journal of Agricultural Science and Technology B 3 (2013) 685-688
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1010.9220&rep=rep1&type=pdf

Nireus. 2019. Nireus Aquaculture.
http://www.nireus.com/1_2/Home

OIE. 2018. World Organisation for Animal Health: Manual of Diagnostic Tests for Aquatic Animals - Aquatic Manual 22/06/2018: CHAPTER 2.3.12. - VIRAL ENCEPHALOPATHY AND RETINOPATHY
http://www.oie.int/index.php?id=2439&L=0&htmfile=chapitre_viral_encephalopathy_retinopathy.htm

OSPAR. 2009. OSPAR Commission: Assessment of Impacts of Mariculture. Biodiversity Series.
https://www.ospar.org/documents?v=7152

Oidtmann B, Thrush M, Denham KL, Peeler E. 2011. International and national biosecurity strategies in aquatic animal health. Aquaculture. 320. 22-33.
10.1016/j.aquaculture.2011.07.032.
https://www.researchgate.net/publication/230667524_International_and_national_biosecurity_strategies_in_aquatic_animal_health

Okocha RC, Olatoye IO, Adedeji OB. 2018. Public Health Rev (2018) 39: 21.
https://doi.org/10.1186/s40985-018-0099-2
https://link.springer.com/article/10.1186/s40985-018-0099-2

Palaiokostas C, Cariou S, Bestin A, Bruant JS, Haffray P, Morin T, Cabon J, Allal F, Vandeputte M, Houston RD. 2018. Genome-wide association and genomic prediction of resistance to viral nervous necrosis in European seabass (Dicentrarchus labrax) using RAD sequencing. Genetics Selection Evolution. 50. 10.1186/s12711-018-0401-2.
https://www.researchgate.net/publication/325657948_Genome-wide_association_and_genomic_prediction_of_resistance_to_viral_nervous_necrosis_in_European_sea_bass_Dicentrarchus_labrax_using_RAD_sequencing/citations

Palenzuela O, Del Pozo R, Piazzon MC, Isern-Subich MM, Ceulemans S, Coutteau P, Sitjà-Bobadilla A. 2017. Functional Feed Additives in Aquaculture: Functional feed additives can reduce the impact of an *Enteromyxum leei* infection on performance and disease severity: evidence from an experimental challenge with gilthead sea bream. *Published in International Aquafeed, July 2017*
https://nutriad.com/2017/08/functional-feed-additives/

Panzarin V, Fusaro A, Monne I, Cappellozza E, Patarnello P, Bovo G, Cattoli G. 2012. *Molecular epidemiology and evolutionary dynamics of betanodavirus in southern Europe. Infection, Genetics and Evolution, 12(1), 63–70.*doi:10.1016/j.meegid.2011.10.007
https://www.researchgate.net/publication/51756143_Molecular_epidemiology_and_evolutionary_dynamics_of_betanodavirus_in_southern_Europe

Pecorino D, Povero P, Olivari E, Chiantore M. 2016. European Aquaculture Society – Aquaculture Europe - Edinburgh, 2016. A European scale comparison of off-shore mariculture farms shows good environmental sustainability and scope for growth. Department of Earth, Environment and Life Sciences (DISTAV), University of Genoa, Corso Europa 26 - 16132, Genoa, Italy.
https://www.was.org/easonline/AbstractDetail.aspx?i=6456

Perdikaris C, Chrysafi A, Ganias K. 2016. Environmentally Friendly Practices and Perceptions in Aquaculture: A Sectoral Case-study from a Mediterranean-based Industry, Reviews in Fisheries Science & Aquaculture, 24:2, 113-125, DOI: 10.1080/23308249.2015.1112358
https://www.tandfonline.com/doi/full/10.1080/23308249.2015.1112358

PerformFISH. 2019. Title: Consumer-driven production: Integrating Innovative Approaches for Competitive and Sustainable Performance across the Mediterranean Aquaculture Value Chain. Grant Agreement: 727610 - Deliverable 3.3, Best therapeutics practices for Mediterranean farmed fish
http://performfish.eu/wp-content/uploads/2019/09/D3.3_Best-therapeutics-practices-for-Mediterranean-farmed-fish.pdf

Pergent-Martini C, Boudouresque CF, Pasqual ini V, Pergent G. 2006. Impact of fish farming facilities on *Posidonia oceanica* meadows: a review. Mar. Ecol., 27: 310-319.
https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1439-0485.2006.00122.x

Piazzon MC, Mladineo I, Naya-Català F, Dirks RP, Jong-Raadsen S, Vrbatovic A, Hrabar J, Pérez-Sánchez J, Sitjà-Bobadilla A. 2019. Acting locally - affecting globally: RNA sequencing of gilthead sea bream with a mild *Sparicotyle chrysophrii* infection reveals effects on apoptosis, immune and hypoxia related genes. BMC Genomics; 20:200. doi: https://doi.org/10.1186/s12864-019-5581-9
https://link.springer.com/epdf/10.1186/s12864-019-5581-9?author_access_token=ApKbgZbwrTf-LEOi8Ybw6m_BpE1tBhCbnbw3BuzI2RPbVw-hlWzShW-IxRMTJX0RzDV4MahDj1tJcADCQiBex2D_xbAguUBjN9BQptnlQSnJV6ssOtALw7Q8RKX9etg2Z6Cgy2RKdmi_NDlQUa38CQ==

Piroddi C, Bearzi G, Christensen V. 2011. Marine open cage aquaculture in the eastern Mediterranean Sea: a new trophic resource for bottlenose dolphins. Mar. Ecol. Prog. Ser. 440, 255–266
https://www.int-res.com/articles/meps2011/440/m440p255.pdf

Plant K, Lapatra S. 2011. Advances in fish vaccine delivery. Developmental and comparative immunology. 35. 1256-62. 10.1016/j.dci.2011.03.007.
https://www.researchgate.net/publication/50419141_Advances_in_fish_vaccine_delivery

Pollard DA, Yokes B, Kara M, Bizsel K, Quignard JP. 2015. *Argyrosomus regius*. The IUCN Red List of Threatened Species 2015: e.T198706A49227019. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T198706A49227019.en. Downloaded on 24 September 2018.
Popovic, N.T., Strunjak-Perovic, I., Coz-Rakovac, R., Barisic, J., Jadan, M., Berakovic, A.P., Klobucar, R.S. 2012. Tricaine methane-sulfonate (MS-222) application in fish anaesthesia. J. Appl. Ichthyol. 28, 553–564.

PreventEscape. 2013. PREVENT ESCAPE Project Compendium (full) - Published on Apr 25, 2013
https://issuu.com/oceanografica/docs/prevent_escape

Price C, Black KD, Hargrave BT, Morris Jr. JA. 2015. Marine cage culture and the environment: effects on water quality and primary production. Aquaculture Environment Interactions - Vol. 6: 151–174, 2015 doi: 10.3354/aei00122
http://www.int-res.com/articles/aei2014/6/q006p151.pdf

Price CS & Morris JA. 2013. Marine Cage Culture and the Environment: Twenty-first Century Science Informing a Sustainable Industry. NOAA Technical Memorandum NOS NCCOS 164. 158 pp.
https://www.researchgate.net/publication/285386836_Marine_Cage_Culture_and_the_Environment_Twenty-first_Century_Science_Informing_a_Sustainable_Industry

Rabassó M, Hernández JM. 2015. Bioeconomic analysis of the environmental impact of a marine fish farm - Journal of Environmental Management 158 (2015) 24e35
https://www.researchgate.net/publication/275894409_Bioeconomic_analysis_of_the_environmental_impact_of_a_marine_fish_farm

Rad F, Şen İ. 2016. Seabass & bream Sector Overview-Turkey Technical Report - September 2016, CERES-Climate Change and European Aquatic Resources, Task 4.2
Effects of Climate Change on Farm-Level Productivity and Profitability
https://www.researchgate.net/publication/320628618_Sea_bass_bream_Sector_Overview-Turkey

Readman, G.D., Owen, S.F., Murrell, J.C., Knowles, T.G. 2013. Do fish perceive anaesthetics as aversive? PLoS One 8 (9), e73773. http://dx.doi.org/10.1371/journal.pone.0073773.

Remberger, M., Woldegiorgis, A., Kaj, L., Andersson, J., Cousins, A.P., Dusan, B., Ekheden, Y., Brorström-Lundén, E. 2006. Results from the Swedish Screening 2005. Subreport 2: Biocides. Swedish Environmental Research Institute.

Represas I, Moretti A. 2017. MEDITERRANEAN MARINE FISH HATCHERIES: UPDATE ON PROGRESS AND TRENDS – Larvi 2017
https://inveaquaculture.com/download/presentation/

Rico A, Vighi M, Van den Brink PJ, ter Horst M, Macken A, Lillicrap A, Falconer L, Telfer TC. 2018. Use of models for the environmental risk assessment of veterinary medicines in European aquaculture: current situation and future perspectives. Reviews in Aquaculture
https://dspace.stir.ac.uk/handle/1893/27440#.Xd5R6C2cbu0

Riera R, Pérez Ó, Cromey C, Rodríguez M, Ramos E, lvarez O, Domínguez J, Monterroso Ó, Tuya F. 2017. MACAROMOD: A tool to model particulate waste dispersion and benthic impact from offshore sea-cage aquaculture in the Macaronesian region - Ecological Modelling 361 (2017) 122–134 - http://dx.doi.org/10.1016/j.ecolmodel.2017.08.006
http://www.rodrigoriera.com/pdf_publications/Riera%20et%20al.%202017%20Ecol%20Modelling.MACAROMOD.pdf

Rigos G, Mladineo I, Nikoloudaki C, Vrbatovic A, Kogiannou D. 2016. Application of compound mixture of caprylic acid, iron and mannan oligosaccharide against Sparicotyle chrysophrii (Monogenea: Polyopisthocotylea) in gilthead sea bream, Sparus aurata. Folia Parasitologica. 2016;63(1):2016.000.
https://folia.paru.cas.cz/pdfs/fol/2016/01/27.pdf

Rogers C. & Basurco B. 2009 . *The use of veterinary drugs and vaccines in Mediterranean aquaculture*. Zaragoza: CIHEAM, 2009. 223 p. (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 86). The Use of Veterinary Drugs and Vaccines in Mediterranean Aquaculture, 2003/05/21-23, Izmir (Turkey).
http://om.ciheam.org/option.php?IDOM=387

Rothuis A, van Duijn AP, Roem A, Ouwehand A, van der Pijl W, Rurangwa E, 2013. *Aquaculture business opportunities in Egypt.* Wageningen, Wageningen UR (University & Research centre), LEI report 2013-039, IMARES report C091/13.
http://edepot.wur.nl/258663

Rountos KJ, Peterson BJ, Karakassis I. 2012. Indirect effects of fish cage aquaculture on shallow Posidonia oceanica seagrass patches in coastal Greek waters - AQUACULTURE ENVIRONMENT INTERACTIONS Aquacult Environ Interact Vol. 2: 105–115, 2012 doi: 10.3354/aei00037
https://www.int-res.com/articles/aei2012/2/q002p105.pdf

Ruiz JM, Marco-Méndez C, Sánchez-Lizaso JL. 2010. Remote influence of offshore fish farm waste on Mediterranean seagrass (*Posidonia oceanica*) meadows. Marine Environmental Research, Elsevier, 2010, 69 (3), pp.118.
https://hal.archives-ouvertes.fr/hal-00565102/document

Russell B, Carpenter KE, Pollard D. 2014. *Sparus aurata*. The IUCN Red List of Threatened Species 2014: e.T170253A1302459. http://dx.doi.org/10.2305/IUCN.UK.2014-3.RLTS.T170253A1302459.en. Downloaded on 24 September 2018.

SEP. 2015. Science for Environment Policy (2015) *Sustainable Aquaculture.* Future Brief 11. Brief produced for the European Commission DG Environment by the Science Communication Unit, UWE, Bristol
http://ec.europa.eu/environment/integration/research/newsalert/pdf/sustainable_aquaculture_FB11_en.pdf

SFP. 2018. Sustainable Fisheries Partnership, FishSource database: an online information resource about the status of fish stocks and fisheries - Accessed 19 July 2018
https://www.fishsource.org

Saad TT & Atallah ST. 2014. Fish diseases and its economic effect on Egyptian fish farms. J. Agric. Food Tech., 4(5): 1–6 (2014).
http://www.arabaqs.org/journal/vol_9/1/Text%2014%20-%2002.pdf

Saad TT. 2013. Some study on heavy metal and bacterial infection relationship in some cultured marine fish. Journal of the Arabian Aquaculture Society, 8, 143–162.
http://www.arabaqs.org/journal/vol_8/1/Text%2013%20-%2013.pdf

Saavedra M, Pereira T, Carvalho L, Pousão P, Grade A, Teixeira B, Quental-Ferreira H, Mendes R, Bandarra N, Gonçalves A. 2017. Wild and Farmed Meagre, Argyrosomus regius : A Nutritional, Sensory and Histological Assessment of Quality Differences. Journal of Food Composition and Analysis. 63. 10.1016/j.jfca.2017.07.028.
https://www.researchgate.net/publication/318448007_Wild_and_Farmed_Meagre_Argyrosomus_regius_A_Nutritional_Sensory_and_Histological_Assessment_of_Quality_Differences

Sadek S. 2013. Aquaculture site selection and carrying capacity estimates for inland and coastal aquaculture in the Arab Republic of Egypt. *In* L.G. Ross, T.C. Telfer, L. Falconer, D. Soto & J. Aguilar-Manjarrez, eds. *Site selection and carrying capacities for inland and coastal aquaculture,* pp. 183–196. FAO/Institute of Aquaculture, University of Stirling, Expert Workshop, 6–8 December 2010. Stirling, the United Kingdom of Great Britain and Northern Ireland. FAO Fisheries and Aquaculture Proceedings No. 21. Rome, FAO. 282 pp.
http://www.fao.org/tempref/FI/CDrom/P21/root/11.pdf

Sahin M. 1995. Seabass and bream in floating cages in Turkey. Aspects économiques de la production aquacole. Zaragoza: CIHEAM, 1995. p. 57-63 (Cahiers Options Méditerranéennes; n. 14)
http://om.ciheam.org/om/pdf/c14/96605649.pdf

Samuelsen, O.B., Lunestad, B.T., Farestveit, E., Grefsrud, E.S., Hannisdal, R., Holmelid, B., Tjensvoll, T., Agnalt, A.L. 2014. Mortality and deformities in European lobster (Homarus gammarus) juveniles exposed to the anti-parasitic drug teflubenzuron. Aquat. Toxicol. 149, 8–15.

Samy-Kamal M. 2015. Status of fisheries in Egypt: reflections on past trends and management challenges - Article in Reviews in Fish Biology and Fisheries · October 2015 DOI: 10.1007/s11160-015-9404-z
https://www.researchgate.net/publication/283553302_Status_of_fisheries_in_Egypt_reflections_on_past_trends_and_management_challenges

Sanchez-Jerez P, Karakassis I, Massa F, Fezzardi D, Aguilar-Manjarrez J, Soto D et al. 2016. Aquaculture's struggle for space: the need for coastal spatial planning and the potential benefits of allocated zones for aquaculture (AZAs) to avoid conflict and promote sustainability. Aquaculture Environment Interactions, 8: 41–54. [Cited 24 January 2018.] Available from URL: www.int-res.com/articles/aei2016/8/q008p041.pdf

Sanchez-Jerez P. 2013. Fish Escapes from Cage Aquaculture in the Mediterranean – World Aquaculture December 2013 – www.was.org
https://pdfs.semanticscholar.org/a7f5/33d664377b08889cc1ed4d82646380dc9000.pdf

Sanchez-Jerez P, Karakassis I. 2011. Allowable zone of effect for Mediterranean marine aquaculture (AZE) GFCM: CAQ/2012/CMWG-5/ Inf. 11
https://rua.ua.es/dspace/bitstream/10045/48461/1/GFCMCAQ2012CMWG-5Inf.11.pdf

Sánchez-Lamadrid A. 2004. Effectiveness of releasing gilthead sea bream (Sparus aurata, L.) for stock enhancement in the bay of Cádiz. Aquac 231 (1), 135–148.
https://www.researchgate.net/search.Search.html?type=publication&query=Effectiveness%20of%20releasing%20gilthead%20sea%20bream%20(Sparus%20aurata,%20L.)%20for%20stock%20enhancement%20in%20the%20bay%20of%20Cádiz

Sánchez-Lamadrid A. 2002. Stock enhancement of gilthead sea bream (Sparus aurata, L.): assessment of season, fish size and place of release in SW Spanish coast. Aquac 210 (1), 187–202.
https://www.researchgate.net/search.Search.html?type=publication&query=Stock%20enhancement%20of%20gilthead%20sea%20bream%20(Sparus%20aurata,%20L.):%20assessment%20of%20season,%20fish%20size%20and%20place%20of%20release%20in%20SW%20Spanish%20coast

Santos MN, Lino PG, Pousão-Ferreira P, Monteiro CC. 2006. Preliminary results of hatchery-reared seabreams released at artificial reefs off the Algarve coast (southern Portugal): a pilot study. Bull. Mar. Sci. 78 (1), 177–184.
https://www.researchgate.net/publication/228918743_Preliminary_results_of_hatchery-reared_seabreams_released_at_artificial_reefs_off_the_Algarve_coast_southern_Portugal_A_pilot_study

Sanz-Lázaro C, Belando M D, Marín-Guirao L, Navarrete-Mier, Marin A. 2011. Relationship between sedimentation rates and benthic impact on Maërl beds derived from fish farming in the Mediterranean - Marine Environmental Research 71, 22-30
https://www.researchgate.net/publication/47532981RelationshipbetweensedimentationratesandbenthicimpactonMaerlbedsderivedfromfishfarmingintheMediterranean

Sanz-Lázaro C, Marín A. 2008. Assessment of Finfish Aquaculture Impact on the Benthic Communities in the Mediterranean Sea - Dynamic Biochemistry, Process Biotechnology and Molecular Biology ©2008 Global Science Books
https://www.researchgate.net/publication/216291698AssessmentofFinfishAquacultureImpactontheBenthicCommunitiesintheMediterraneanSea

Sanz-Lázaro C, Marín A. 2006. Benthic recovery during open sea fish farming abatement in Western Mediterranean, Spain. Marine Environmental Research 62, 374-387
https://www.researchgate.net/publication/6897143BenthicrecoveryduringopenseafishfarmingabatementinWesternMediterraneanSpain

Scarano C, Spanu C, Ziino G, & Pedonese F, Dalmasso A, Spanu V, & Virdis S, De Santis EPL. 2014. Antibiotic resistance of Vibrio species isolated from Sparus aurata reared in Italian mariculture. The New Microbiologica: official journal of the Italian Society for Medical Virology (SIVIM). 37. 329-337
https://www.researchgate.net/profile/Salvatore_Virdis/publication/264273747_Antibiotic_resistance_of_Vibrio_species_isolated_from_Sparus_aurata_reared_in_Italian_mariculture/links/53d66e8a0cf220632f3da0d0.pdf

Seafish. 2019. Aquaculture Profile: European Seabass - *Dicentrachus labrax*
https://www.seafish.org/aquaculture/profile/26

Seafish. 2016. Fishmeal and Fish Oil Facts and Figures - December 2016
http://www.seafish.org/media/publications/SeafishFishmealandFishOilFactsandFigures_201612.pdf

Seafish. 2015. Responsible Sourcing Guide: Farmed Seabass
http://www.seafish.org/media/1403318/_2_sea_bass_rsg-cocker_04-15kg.pdf

SeafoodSource. 2019. Andromeda Seafood Group closes on purchase of Nireus and Selonda - By Madelyn Kearns, Nov 27, 2019
https://www.seafoodsource.com/news/business-finance/andromeda-seafood-group-closes-on-purchase-of-nireus-and-selonda?utm_source=marketo&utm_medium=email&utm_campaign=newsletter&utm_content=newsletter&mkt_tok=eyJpIjoiTmpRd05XUmxOakV4TWpsbCIsInQiOiJXdGxRbnBZTE1QdVpqQVZpK2RER2VFcnQ5Q2JlbmMxTHgzVE5NcUxJS3U0MUg3SytLMll1RzVpVGJ3alhDRDhUUGM4QmhCVVVCU3M1UXNyT0EwQVFDUkZqckEyZk9uY3Q1dHN2dHhRd2l1aUNXUnVJOW53ZVo2anZYdDZqVE1xXC8ifQ%3D%3D

SeafoodSource. 2018a. Record exports for leading bass, bream producer. By Jason Holland, Feb 8, 2018.
https://www.seafoodsource.com/news/aquaculture/record-exports-for-leading-bass-bream-producer?utmsource=informz&utmmedium=email&utmcampaign=newsletter&utmcontent=newsletter

SeafoodSource. 2018b. Kilic's Sinan Kızıltan sees meagre hope in US market - By Cliff White March 15, 2018
https://www.seafoodsource.com/news/supply-trade/kilics-sinan-kiziltan-sees-meagre-hope-in-us-market?utmsource=informz&utmmedium=email&utmcampaign=newsletter&utmcontent=newsletter

Šegvić-Bubić T, Arechavala-Lopez P, Vučić I, Talijančić I, Grubišić L, Žužul I, Kovač Ž. 2018. Site fidelity of farmed gilthead seabream Sparus aurata escapees in a coastal environment of the Adriatic Sea - Aquaculture Environment Interactions Vol. 10: 21–34, 2018
https://www.int-res.com/articles/aei2018/10/q010p021.pdf

Šegvić-Bubić T, Grubišić L, Trumbić Ž, Stanić R, Ljubković J, Maršić-Lučić J, Katavić I. 2017. Genetic characterization of wild and farmed European seabass in the Adriatic sea: assessment of farmed escapees using a Bayesian approach, *ICES Journal of Marine Science*, Volume 74, Issue 1, 1 January 2017, Pages 369–378
https://academic.oup.com/icesjms/article/74/1/369/2669571

Šegvić-Bubić T, Talijan I, Grubiši L, Izquierdo-Gomez D, Katavi I. 2014. Morphological and molecular differentiation of wild and farmed gilthead sea bream Sparus aurata : implications for management - Aquacult Environ Interact 6: 43–54, 2014
https://www.int-res.com/articles/aei2014/6/q006p043.pdf

Selonda. 2019. Selonda: "The world's largest producer and supplier of Sea Bream and Seabass." http://www.selonda.com/en/

Séminaires Méditerranéens; n. 86). The Use of Veterinary Drugs and Vaccines in Mediterranean Aquaculture, 2003/05/21-23, Izmir (Turkey).
http://om.ciheam.org/option.php?IDOM=387#prettyPhoto

Shaalan M, El-Mahdy M, Saleh M, El-Matbouli M. 2017. Aquaculture in Egypt: Insights on the Current Trends and Future Perspectives for Sustainable Development - Reviews in Fisheries Science & Aquaculture, DOI:10.1080/23308249.2017.1358696
https://www.researchgate.net/publication/319241690_Aquaculture_in_Egypt_Insights_on_the_Current_Trends_and_Future_Perspectives_for_Sustainable_Development

Soares F, Roque A, Gavaia P. 2018. Review of the principal diseases affecting cultured meagre (Argyrosomus regius). Aquaculture Research. 10.1111/are.13613 https://www.researchgate.net/publication/322664241_Review_of_the_principal_diseases_affecting_cultured_meagre_Argyrosomus_regius

Soares F, Ribeiro L, Gamboa M, Duarte S, Mendes A, Castanho S, Barata M, Margarida Lourenço T, Pousão-Ferreira P. 2015. Comparative analysis on natural spawning of F1 meagre, Argyrosomus regius, with wild broodstock spawns in Portugal. Fish physiology and biochemistry. 41. 10.1007/s10695-015-0103-4.
https://www.researchgate.net/publication/280327511_Comparative_analysis_on_natural_spawning_of_F1_meagre_Argyrosomus_regius_with_wild_broodstock_spawns_in_Portugal

Sola L, Moretti A, & Crosetti D, Karaiskou N, Magoulas A, Rossi AR, Rye M, Triantafyllidis A, Tsigenopoulos C. 2006. Gilthead seabream -Sparus aurata.
https://www.researchgate.net/publication/265870587_Gilthead_seabream_-Sparus_aurata

Soliman NF. 2017. Aquaculture in Egypt under changing climate - challenges and opportunities. Working Paper (4), Alexandria Research Center for Adaptation to Climate Change (ARCA)
http://arca-eg.org/wp-content/uploads/2017/06/Working-Paper-4-Jan.2017.pdf

Soliman NF & Yacout DMM. 2016. Aquaculture in Egypt: status, constraints and potentials. Aquaculture International. 24. 10.1007/s10499-016-9989-9
https://www.researchgate.net/publication/297893258AquacultureinEgyptstatusconstraintsandpotentials

Soliman NF & Yacout DMM. 2015. The Prospects of Analysing the Environmental Impacts of Egyptian Aquaculture Using Life Cycle Assessment, International Journal of Aquaculture, 5(40): 1-9 (doi: 10.5376/ija.2015.05.0040)
http://biopublisher.ca/index.php/ija/article/view/2128

Somarakis S, Pavlidis M, Saapoglou C, Tsigenopoulos CS, Dempster T. 2013. Evidence for 'escape through spawning' in large gilthead sea bream Sparus aurata reared in commercial sea-cages - Aquacult Environ Interact 3: 135–152, 2013
https://www.researchgate.net/publication/259463494_Evidence_for_%27escape_through_spawning%27_in_large_gilthead_sea_bream_Sparus_aurata_reared_in_commercial_sea-cages

Spinos E, Gerakis A, Palaiologos A Bakopoulos V. 2019. Effects of Temperature and Salinity on Outbreaks of Bacterial Diseases of Farmed Seabass Dicentrarchus Labrax (Linnaeus, 1758).
https://www.researchgate.net/publication/332849764_EFFECTS_OF_TEMPERATURE_AND_SALINITY_ON_OUTBREAKS_OF_BACTERIAL_DISEASES_OF_FARMED_SEA_BASS_DICENTRARCHUS_LABRAX_LINNAEUS_1758

Spinos E, Kokkoris G, Bakopoulos V. 2017. Prevention of seabass (Dicentrarchus labrax, L. 1758) photobacteriosis and vibriosis. Long term efficacy study of intraperitoneally administered bivalent commercial vaccines. Aquaculture. 471. 10.1016/j.aquaculture.2017.01.017.

https://www.researchgate.net/publication/312659754_Prevention_of_sea_bass_Dicentrarchus_labrax_L_1758_photobacteriosis_and_vibriosis_Long_term_efficacy_study_of_intraperitoneally_administered_bivalent_commercial_vaccines

Studer BH. 2018. Sparus aurata (Summary). In: FishEthoBase, ed. FishEthoBase Research Group. World Wide Web electronic publication. Version 1.1. www.fishethobase.net.»
© fair-fish international
http://fishethobase.net/en/db/49/

Subasinghe R. 2009. Disease control in aquaculture and the responsible use of veterinary drugs and vaccines: The issues, prospects and challenges. Options Méditerranéennes. 86.
https://www.researchgate.net/publication/267223916_Disease_control_in_aquaculture_and_the_responsible_use_of_veterinary_drugs_and_vaccines_The_issues_prospects_and_challenges

Svåsand T, Crosetti D, García-Vázquez E, Verspoor E. (eds). 2007. Genetic impact of aquaculture activities on native populations. Genimpact final scientific report (EU contract n. RICA-CT-2005-022802). 176 p. http://genimpact.imr.no/
https://www.imr.no/genimpact/filarkiv/2007/07/genetic_impact_of_aquaculture.pdf/en

Tacon, A.G.J., M.R. Hasan, and M. Metian. 2011. Demand and supply of feed ingredients for farmed fish and crustaceans- trends and prospects. FAO Fisheries and Aquaculture Technical Paper 564. Food and Agricultural Organization of the United Nations, Rome.
http://www.fao.org/docrep/015/ba0002e/ba0002e00.htm

Talijančić I, Šegvić-Bubić T, Žužul I, Grubišić L, Tičina V, Katavić I. 2017. European Aquaculture Society - Meeting Aquaculture Europe 2017 Dubrovnik, Croatia - PHENOTYPIC DELINEATION OF WILD AND FARMED GILTHEAD SEABREAM Sparus aurata (L. 1758)
http://jadran.izor.hr/~tsegvic/aquapop/images/EAS_IT.pdf

Telfer T, Falconer L, Kaas H, Jackson D. 2018. TAPAS - Tools for Assessment and Planning of Aquaculture Sustainability - Horizon2020, in
Impact, Volume 2018, Number 8, November 2018, pp. 9-11(3), Science Impact Ltd
DOI: https://doi.org/10.21820/23987073.2018.8.9
https://www.ingentaconnect.com/content/sil/impact/2018/00002018/00000008/art00004#

Telfer TC, Atkin H, Corner RA. 2009. Review of environmental impact assessment and monitoring in aquaculture in Europe and North America. In FAO. Environmental impact assessment and monitoring in aquaculture. *FAO Fisheries and Aquaculture Technical Paper*. No. 527. Rome, FAO. pp. 285–394.
http://www.fao.org/tempref/docrep/fao/012/i0970e/i0970e01d.pdf

Telfer, T.C., Baird, D.J., McHenery, J.G., Stone, J., Sutherland, I., Wislocki, P. 2006. Environmental effects of the anti-sea lice (Copepoda: Caligidae) therapeutant emamectin benzoate under commercial use conditions in the marine environment. Aquaculture 260, 163–180.

The Fish Site. 2016. Sustainable Aquaculture Magazine – May 2016
https://www.diversifyfish.eu/uploads/1/4/2/0/14206280/678888-sustainable_aq_selected-pages.pdf

The Fish Site. 2010. France Fishery Products
https://thefishsite.com/articles/france-fishery-products

The Fish Site. 2009. How to Farm Meagre Fish – by Lucy Towers – 11 November 2009
https://thefishsite.com/articles/cultured-aquatic-species-meagre-fish

Theodorou JA, Perdikaris C, Filippopoulos NG. 2015. Evolution Through Innovation in Aquaculture: A Critical Review of the Greek Mariculture Industry, Journal of Applied Aquaculture, 27:2, 160-181
https://www.researchgate.net/publication/280315454EvolutionthroughinnovationinaquacultureAcriticalreviewoftheGreekmaricultureindustry

Timur G, Ürkü Ç, Çanak Ö, Erköse Genç G, Erturan Z. 2015. A Systemic Mycobacteriosis in Farmed Meagre (Argyrosomus regius) Caused by Mycobacterium marinum in Turkey. The Israeli journal of aquaculture = Bamidgeh. 67. IJA_67.2015.1162, 8 pages.
https://www.researchgate.net/publication/274512869_A_Systemic_Mycobacteriosis_in_Farmed_Meagre_Argyrosomus_regius_Caused_by_Mycobacterium_marinum_in_Turkey

Today. 2010. Statement from FDA about imported seafood **-** Nov. 2010
https://www.today.com/news/statement-fda-about-imported-seafood-wbna40218600

Toffan A. 2017. Viral nervous necrosis in gilthead sea bream (*Sparus aurata*) caused by reassortant betanodavirus RGNNV/SJNNV: an emerging threat for Mediterranean aquaculture - Scientific RepoRts | 7:46755 | DOI: 10.1038/srep46755
https://www.nature.com/articles/srep46755.pdf

Toledo-Guedes K, Sanchez-Jerez P, Brito A. 2014. Influence of a massive aquaculture escape event on artisanal fisheries. Fish. Manag. Ecol. 21 (2), 113–121.
https://onlinelibrary.wiley.com/doi/abs/10.1111/fme.12059

Tornero V & Hanke G. 2016. Chemical contaminants entering the marine environment from sea-based sources: A review with a focus on European seas. Marine Pollution Bulletin. 112. 10.1016/j.marpolbul.2016.06.091.
https://www.sciencedirect.com/science/article/pii/S0025326X16304957

TripSavvy. 2018. Meltemi: The Legendary Greek Wind
https://www.tripsavvy.com/meltemi-wind-1524562

Troell M, Kautsky N, Beveridge M, Henriksson P, Primavera J, Rönnbäck P, Folke C, Jonell M. 2017. Aquaculture. 10.1016/B978-0-12-809633-8.02007-0
https://www.researchgate.net/publication/312003068_Aquaculture

Tsikopoulou I, Smith CJ, Papadopoulou N, Tsapakis M, Karakassis I. 2019. Επίδραση δύο ανθρωπογενών δραστηριοτήτων στο θαλάσσιο οικοσύστημα: επανεξέταση βενθικών κοινοτήτων 20 χρόνια μετά.
https://www.researchgate.net/publication/337889191_Epidrase_dyo_anthropogenon_drasterioteton_sto_thalassio_oikosystema_epanexetase_benthikon_koinoteton_20_chronia_meta

Tsikopoulou I, Moraitis ML, Tsapakis M, Karakassis I. 2018. Can intensive fish farming for 20 years induce changes in benthic ecosystems on a scale of waterbody? An assessment from Cephalonia bay (Ionian Sea) - Environ Monit Assess (2018) 190:469
https://doi.org/10.1007/s10661-018-6846-5
https://www.researchgate.net/requests/r55567908

UCN. 2018. Egyptian farmed bass output rockets, Turkish, Greek rises – July 31 2018
https://www.undercurrentnews.com/2018/07/31/egyptian-farmed-bass-output-rockets-turkish-greek-rises/?utm_source=Undercurrent+News+Alerts&utm_campaign=8b2e384c2e-Aquaculture_roundup_Aug_06_2018&utm_medium=email&utm_term=0_feb55e2e23-8b2e384c2e-92579545

UCN. 2017. Undercurrent News - Consultant explains why seabass, seabream sector is stuck in price doldrums by Louis Harkell, Sep. 1, 2017
https://www.undercurrentnews.com/2017/09/01/consultant-explains-why-seabass-seabream-sector-is-stuck-in-price-doldrums/

UNDP. 2011. United Nations Development Programme: Egypt's National Strategy for Adaptation to Climate Change and Disaster Risk Reduction
http://www.climasouth.eu/docs/Adaptation011%20StrategyEgypt.pdf

US Census Bureau. 2018.
https://www.census.gov/foreign-trade/data/index.html

USAID. 2000. ANALYSIS AND REVIEW OF MODIFICATIONS IN LAW 12 OF 1984 ON IRRIGATION AND DRAINAGE - Author(s): Sarwat Fahmy, Dr. Ibrahim Elassiouty, Nasser Ezzat , Ahmed Maher , Dr. Mohamed Badran
https://rmportal.net/library/content/tools/environmental-policy-and-institutional-strengthening-epiq-iqc/epiq-environmental-policy-and-institutional-strengthening-cd-vol-1/epiq-cd-1-technical-area-policy-assessment-analysis-and-evaluation-strategic-planning/analysis-and-review-of-modifications-in-law-12-of-1984-on-irrigation-and-drainage/view

USDA FAS. 2018. United States Department of Agriculture – Foreign Agricultural Service – Global Agricultural Trade System Online (GATS).
https://apps.fas.usda.gov/gats/default.aspx

USDA FAS. 2016. Global Agricultural Information Network (GAIN) report: The State and Development of Aquaculture in Egypt 11/6/2016 - Prepared by Ahmed Wally
https://gain.fas.usda.gov/Recent%20GAIN%20Publications/The%20State%20and%20Development%20of%20Aquaculture%20in%20Egypt%20_Cairo_Egypt_11-6-2016.pdf

USFWS. 2010. United States Fish and Wildlife Service Aquatic Animal Drug Approval Program – Reference Guide to Approved Drugs for use in Aquaculture
https://www.fws.gov/fisheries/aadap/PDF/approveddrugs.pdf

Van den Brink PJ, Kalantzi I, Tsapakis M, Apostolaki ET, Penry-Williams IL, de Kock W, Escobar Sierra C, Mylona K, Chatzigeorgiou G, Torres R, Dale T, Ferincz A, Ács A, García Bueno N, Marín A, Rico A. 2019. Report and scientific articles on the case studies & model validation. IMDEA Water Institute (Spain) - EU H2020 TAPAS Deliverable 3.6. Report. 92 pp.
https://webcache.googleusercontent.com/search?q=cache:0Kv1B9Hur6AJ:https://ec.europa.eu/research/participants/documents/downloadPublic%3FdocumentIds%3D080166e5c2036739%26appId%3DPPGMS+&cd=4&hl=en&ct=clnk&gl=uk&client=safari

Vandeputte M, Gagnaire P, Allal F. 2019. The European seabass: a key marine fish model in the wild and in aquaculture. Anim Genet, 50: 195-206. doi:10.1111/age.12779
https://onlinelibrary.wiley.com/doi/full/10.1111/age.12779

Varadi L, Szucs I, Pekar F, Blokhin S, Csavas I. 2001. Aquaculture development trends in Europe. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 397-416. NACA, Bangkok and FAO, Rome.
http://www.fao.org/docrep/003/ab412e/ab412e24.htm

Veldhoen, N., Ikonomou, M.G., Buday, C., Jordan, J., Rehaume, V., Cabecinha,M., Dubetz, C., Chamberlain, J., Pittroff, S., Vallée, K., van Aggelen, G., Helbing, C.C. 2012. Biological effects of the anti-parasitic chemotherapeutant emamectin benzoate on a non-target crustacean, the spot prawn (Pandalus platyceros Brandt, 1851) under laboratory conditions. Aquat. Toxicol. 108, 94–105.

Vendramin N, Zrncic S, Padrós F, Oraic D, Le Breton A, Zarza C, Olesen NJ. 2016. Fish health in Mediterranean Aquaculture, past mistakes and future challenges. Bulletin of the European Association of Fish Pathologists, 36(1), 38–45.
http://orbit.dtu.dk/en/publications/fish-health-in-mediterranean-aquaculture-past-mistakes-and-future-challenges(9a1deeeb-7535-4241-aa69-37d875a644e8).html
https://bib.irb.hr/datoteka/801957.Zrncic_workshop_report.pdf

Vendramin N, Patarnello P, Toffan A, Panzarin V, Cappellozza E, et al. 2013a. Viral encephalopathy and retinopathy in groupers (*Epinephelus spp.*) in southern Italy: a threat for wild endangered species? *BMC Vet. Res.* 9:20
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3566913/

Vendramin N, Toffan A, Mancin M, & Cappellozza E & Panzarin V, Bovo G & Cattoli G, Capua I, Terregino C. 2013b. Comparative pathogenicity study of ten different Betanodavirus strains in experimentally infected European seabass, Dicentrarchus labrax (L.). Journal of fish diseases. 37. 10.1111/jfd.12117.
https://www.researchgate.net/publication/236688858_Comparative_pathogenicity_study_of_ten_different_Betanodavirus_strains_in_experimentally_infected_European_sea_bass_Dicentrarchus_labrax_L

Vollenweider RA, Giovanardi F, Montanari G, Rinaldi A. 1998. Characterization of the trophic conditions of marine coastal waters, with special reference to the NW Adriatic Sea. Proposal for a trophic scale, turbidity and generalized water quality index. Environmetrics, 9, 329–357
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.473.7203&rep=rep1&type=pdf

Volpe E, Grodzki M, Panzarin V, Guercio A, Purpari G, Serratore P, Ciulli S. 2017. Detection and molecular characterization of betanodaviruses retrieved from bivalve molluscs. Journal of Fish Diseases. 41. 10.1111/jfd.12759
https://www.ncbi.nlm.nih.gov/pubmed/29205402

WHO. 2019. Critically important antimicrobials for human medicine, 6th revision. Geneva: World Health Organization; 2019. Licence: CC BY-NC-SA 3.0 IGO.
https://apps.who.int/iris/bitstream/handle/10665/312266/9789241515528-eng.pdf?ua=1

Wells RS, Natoli A, Braulik G. 2019. *Tursiops truncatus*. *The IUCN Red List of Threatened Species* 2019: e.T22563A50377908. http://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T22563A50377908.en. Downloaded on 25 June 2019.
https://www.iucnredlist.org/species/22563/50377908

White P. 2017. "Aquaculture Pollution: An Overview of Issues with a Focus on China, Vietnam, and the Philippines." Prepared for the World Bank, Washington, DC.
http://documents.worldbank.org/curated/en/557811516773201244/pdf/122927-WP-P153343-PUBLIC-Aquaculture-working-paper.pdf

Yanong RPE. 2016.Viral Nervous Necrosis (Betanodavirus) Infections in Fish - FA180, one of a series of the Department of Fisheries and Aquatic Sciences, UF/IFAS Extension. Original publication date December 2010. Reviewed September 2016. Visit the EDIS website at http://edis.ifas.ufl.edu.
https://edis.ifas.ufl.edu/pdffiles/FA/FA18000.pdf

YouTube. 2012. Intensive desert farming of marine fish in Egypt **-** Fish species cultured are European seabass (*Dicentrachus labrax*) and gilthead seabream (*Sparus aurata*) https://www.youtube.com/watch?v=P1PPu1tXxWc

Yucel-Gier G, Orhan U, Kucuksezgin F. 2009. Regulating and monitoring marine finfish aquaculture in Turkey. Journal of Applied Ichthyology. 25. 686 - 694. 10.1111/j.1439-0426.2009.01367.x. https://www.researchgate.net/publication/229871947_Regulating_and_monitoring_marine_finfish_aquaculture_in_Turkey

Yücel-Gier G, Uslu O, Kucuksezgin F. 2009. Regulating and Monitoring Marine Finfish Aquaculture in Turkey. *J. Appl. Ichthyol. (25). Pp. 686-694.* https://www.researchgate.net/publication/229871947_Regulating_and_monitoring_marine_finfish_aquaculture_in_Turkey

Yücel-Gier G, Kucuksezgin F, Kocak F. 2007. Effects of fish farming on nutrients and benthic community structure in the Eastern Aegean (Turkey). Aquaculture Research. 38. 256 - 267. 10.1111/j.1365-2109.2007.01661.x. https://www.researchgate.net/publication/229563041EffectsoffishfarmingonnutrientsandbenthiccommunitystructureintheEasternAegeanTurkey

Žužul I, Šegvić-Bubić T, Talijančić I, Mandić I, Grubišić L, Katavić I, Maršić-Lučić J. 2017. European Aquaculture Society - Meeting Aquaculture Europe 2017 Dubrovnik, Croatia -GENETICS STRUCTURE OF GILTHEAD SEA BREAM Sparus aurata IN THE ADRIATIC SEA INFERRED WITH MICROSATELLITE MARKERS http://jadran.izor.hr/~tsegvic/aquapop/images/EAS_IZ.pdf

Appendix 1 - Data points and all scoring calculations

Note that 9 of the 10 criteria have been assessed and scored separately for two discrete geographical regions: the European Union and Turkey; and Egypt. This was necessary due to the differences in production practices and legislative framework in either geographical area. The remaining criterion, Feed, was assessed separately for each fish, since the bespoke commercial feeds used to culture gilthead seabream, European seabass and meagre each have a slightly different profile.

Criterion 1: Data quality and availability – EU

Data Category	Data Quality (0-10)	
Industry or production statistics	10	
Management	7.5	
Effluent	7.5	
Habitats	7.5	
Chemical use	5	
Feed	7.5	
Escapes	7.5	
Disease	5	
Source of stock	10	
Predators and wildlife	5	
Unintentional introduction	10	
Other – (e.g. GHG emissions)	n/a	
Total	**82.5**	
C1 Data Final Score (0-10)	**7.5**	**GREEN**

Criterion 1: Data quality and availability – Turkey

Data Category	Data Quality (0-10)	
Industry or production statistics	10	
Management	7.5	
Effluent	7.5	
Habitats	7.5	
Chemical use	2.5	
Feed	7.5	
Escapes	7.5	
Disease	5	

Source of stock	10	
Predators and wildlife	5	
Unintentional introduction	10	
Other – (e.g. GHG emissions)	n/a	
Total	**80**	
C1 Data Final Score (0-10)	**7.27**	**GREEN**

Criterion 1: Data quality and availability – Egypt

Data Category	**Data Quality (0-10)**	
Industry or production statistics	7.5	
Management	2.5	
Effluent	2.5	
Habitats	2.5	
Chemical use	0	
Feed	2.5	
Escapes	7.5	
Disease	2.5	
Source of stock	2.5	
Predators and wildlife	0	
Unintentional introduction	10	
Other – (e.g. GHG emissions)	n/a	
Total	**42.5**	
C1 Data Final Score (0-10)	**3.64**	**YELLOW**

Criterion 2: Effluents – EU & Turkey

Effluent Evidence-Based Assessment		
C2 Effluent Final Score (0-10)	**5**	**YELLOW**
Critical?	NO	

Criterion 2: Effluents – Egypt

Factor 2.1 - Biological waste production and discharge

Factor 2.1a - Biological waste production

Protein content of feed (%)	
eFCR	
Fertilizer N input (kg N/ton fish)	
Protein content of harvested fish (%)	
N content factor (fixed)	
N input per ton of fish produced (kg)	
N in each ton of fish harvested (kg)	
Waste N produced per ton of fish (kg)	**125.85**

Factor 2.1b - Production System discharge

Basic production system score	1
Adjustment 1 (if applicable)	0
Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score (0-1)	**1**

% of the waste produced by the fish is discharged from the farm

Factor 2.1 Score - Waste discharge score

Waste discharged per ton of production (kg N ton-1)	125.85
Waste discharge score (0-10)	**0**

Factor 2.2 – Management of farm-level and cumulative effluent impacts

2.2a Content of effluent management measure	1
2.2b Enforcement of effluent management measures	1
2.2 Effluent management effectiveness	**0.4**

C2 Effluent Final Score (0-10)	**0.00**	**RED**
Critical?	YES	

Criterion 3: Habitat – EU & Turkey

Factor 3.1. Habitat conversion and function			
	F3.1 Score (0-10)	7	
Factor 3.2 – Management of farm-level and cumulative habitat impacts			
	3.2a Content of habitat management measure	4	
	3.2b Enforcement of habitat management measures	3	
	3.2 Habitat management effectiveness	**4.8**	
	C3 Habitat Final Score (0-10)	**6**	**YELLOW**
	Critical?	NO	

Criterion 3: Habitat – Egypt

Factor 3.1. Habitat conversion and function			
	F3.1 Score (0-10)	4	
Factor 3.2 – Management of farm-level and cumulative habitat impacts			
	3.2a Content of habitat management measure	2	
	3.2b Enforcement of habitat management measures	0	
	3.2 Habitat management effectiveness	**0**	
	C3 Habitat Final Score (0-10)	**3**	**RED**
	Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use – EU

Chemical Use parameters	**Score**	
C4 Chemical Use Score (0-10)	**3**	
C4 Chemical Use Final Score (0-10)	**3**	**RED**
Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use – Turkey

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	1	
C4 Chemical Use Final Score (0-10)	**1**	**RED**
Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use – Egypt

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	0	
C4 Chemical Use Final Score (0-10)	**0**	**RED**
Critical?	NO	

Criterion 5: Feed – Seabream

5.1. Wild Fish Use			
	Feed parameters	**Score**	
	5.1a Fish In: Fish Out (FIFO)		
	Fishmeal inclusion level (%)	17	
	Fishmeal from by-products (%)	59	
	% FM	6.97	
	Fish oil inclusion level (%)	10	
	Fish oil from by-products (%)	69	
	% FO	3.1	
	Fishmeal yield (%)	24	
	Fish oil yield (%)	5	
	eFCR	2	
	FIFO fishmeal	0.58	
	FIFO fish oil	1.24	
	FIFO Score (0-10)	**6.90**	
	Critical?	NO	
	5.1b Sustainability of Source fisheries		
	Sustainability score	-6	
	Calculated sustainability adjustment	-1.49	
	Critical?	NO	
	F5.1 Wild Fish Use Score (0-10)	**5.41**	

	Critical?	NO	
5.2 Net protein Gain or Loss			
	Protein INPUTS		
	Protein content of feed (%)	44	
	eFCR	2	
	Feed protein from fishmeal (%)		
	Feed protein from EDIBLE sources (%)	81.09	
	Feed protein from NON-EDIBLE sources (%)	18.91	
	Protein OUTPUTS		
	Protein content of whole harvested fish (%)	19.2	
	Edible yield of harvested fish (%)	100	
	Use of non-edible by-products from harvested fish (%)	0	
	Total protein input kg/100kg fish	88	
	Edible protein IN kg/100kg fish	71.36	
	Utilized protein OUT kg/100kg fish	35.89	
	Net protein gain or loss (%)	-49.71	
	Critical?	NO	
	F5.2 Net protein Score (0-10)	**5**	
5.3. Feed Footprint			
	5.3a Ocean Area appropriated per ton of seafood		
	Inclusion level of aquatic feed ingredients (%)		27
	eFCR		2
	Carbon required for aquatic feed ingredients (ton C/ton fish)		*69.7*
	Ocean productivity (C) for continental shelf areas (ton C/ha)		*2.68*
	Ocean area appropriated (ha/ton fish)		14.04
	5.3b Land area appropriated per ton of seafood		
	Inclusion level of crop feed ingredients (%)		70.56
	Inclusion level of land animal products (%)		3.75
	Conversion ratio of crop ingredients to land animal products		*2.88*
	eFCR		2
	Average yield of major feed ingredient crops (t/ha)		*2.64*
	Land area appropriated (ha per ton of fish)		0.62
	Total area (Ocean + Land Area) (ha)		14.66
	F5.3 Feed Footprint Score (0-10)		5

Feed Final Score			
	C5 Feed Final Score (0-10)	**5.21**	**YELLOW**
	Critical?	**NO**	

Criterion 5: Feed – Seabass

5.1. Wild Fish Use			
	Feed parameters	**Score**	
	5.1a Fish In: Fish Out (FIFO)		
	Fishmeal inclusion level (%)	16	
	Fishmeal from by-products (%)	62	
	% FM	6.08	
	Fish oil inclusion level (%)	10	
	Fish oil from by-products (%)	81	
	% FO	1.9	
	Fishmeal yield (%)	24	
	Fish oil yield (%)	5	
	eFCR	2.3	
	FIFO fishmeal	0.58	
	FIFO fish oil	0.87	
	FIFO Score (0-10)	**7.82**	
	Critical?	NO	
	5.1b Sustainability of Source fisheries		
	Sustainability score	-6	
	Calculated sustainability adjustment	-1.05	
	Critical?	NO	
	F5.1 Wild Fish Use Score (0-10)	**6.77**	
	Critical?	NO	
5.2 Net protein Gain or Loss			
	Protein INPUTS		
	Protein content of feed (%)	42	
	eFCR	2.3	
	Feed protein from fishmeal (%)		
	Feed protein from EDIBLE sources (%)	80.54	
	Feed protein from NON-EDIBLE sources (%)	19.46	
	Protein OUTPUTS		

	Protein content of whole harvested fish (%)	18.9	
	Edible yield of harvested fish (%)	100	
	Use of non-edible by-products from harvested fish (%)	0	
	Total protein input kg/100kg fish	96.6	
	Edible protein IN kg/100kg fish	77.80	
	Utilized protein OUT kg/100kg fish	37.02	
	Net protein gain or loss (%)	-52.41	
	Critical?	NO	
	F5.2 Net protein Score (0-10)	**4**	
5.3. Feed Footprint			
	5.3a Ocean Area appropriated per ton of seafood		
	Inclusion level of aquatic feed ingredients (%)		26
	eFCR		2.3
	Carbon required for aquatic feed ingredients (ton C/ton fish)		*69.7*
	Ocean productivity (C) for continental shelf areas (ton C/ha)		*2.68*
	Ocean area appropriated (ha/ton fish)		15.55
	5.3b Land area appropriated per ton of seafood		
	Inclusion level of crop feed ingredients (%)		70.91
	Inclusion level of land animal products (%)		3.75
	Conversion ratio of crop ingredients to land animal products		*2.88*
	eFCR		2.3
	Average yield of major feed ingredient crops (t/ha)		*2.64*
	Land area appropriated (ha per ton of fish)		0.71
	Total area (Ocean + Land Area) (ha)		16.26
	F5.3 Feed Footprint Score (0-10)		4
Feed Final Score			
	C5 Feed Final Score (0-10)	**5.38**	**YELLOW**
	Critical?	**NO**	

Criterion 5: Feed – Meagre

5.1. Wild Fish Use			
	Feed parameters	**Score**	
	5.1a Fish In: Fish Out (FIFO)		
	Fishmeal inclusion level (%)	29	
	Fishmeal from by-products (%)	40	
	% FM	17.4	
	Fish oil inclusion level (%)	12	
	Fish oil from by-products (%)	64	
	% FO	4.32	
	Fishmeal yield (%)	24	
	Fish oil yield (%)	5	
	eFCR	1.7	
	FIFO fishmeal	1.23	
	FIFO fish oil	1.47	
	FIFO Score (0-10)	**6.33**	
	Critical?	NO	
	5.1b Sustainability of Source fisheries		
	Sustainability score	-6	
	Calculated sustainability adjustment	-1.76	
	Critical?	NO	
	F5.1 Wild Fish Use Score (0-10)	**4.57**	
	Critical?	NO	
5.2 Net protein Gain or Loss			
	Protein INPUTS		
	Protein content of feed (%)	43	
	eFCR	1.7	
	Feed protein from fishmeal (%)		
	Feed protein from EDIBLE sources (%)	78.31	
	Feed protein from NON-EDIBLE sources (%)	21.69	
	Protein OUTPUTS		
	Protein content of whole harvested fish (%)	20.1	
	Edible yield of harvested fish (%)	100	
	Use of non-edible by-products from harvested fish (%)	0	
	Total protein input kg/100kg fish	73.1	
	Edible protein IN kg/100kg fish	57.24	
	Utilized protein OUT kg/100kg fish	30.67	

	Net protein gain or loss (%)	-46.42	
	Critical?	NO	
	F5.2 Net protein Score (0-10)	**5**	
5.3. Feed Footprint			
	5.3a Ocean Area appropriated per ton of seafood		
	Inclusion level of aquatic feed ingredients (%)		41
	eFCR		1.7
	Carbon required for aquatic feed ingredients (ton C/ton fish)		*69.7*
	Ocean productivity (C) for continental shelf areas (ton C/ha)		*2.68*
	Ocean area appropriated (ha/ton fish)		18.13
	5.3b Land area appropriated per ton of seafood		
	Inclusion level of crop feed ingredients (%)		51.4
	Inclusion level of land animal products (%)		3.75
	Conversion ratio of crop ingredients to land animal products		*2.88*
	eFCR		1.7
	Average yield of major feed ingredient crops (t/ha)		*2.64*
	Land area appropriated (ha per ton of fish)		0.40
	Total area (Ocean + Land Area) (ha)		18.53
	F5.3 Feed Footprint Score (0-10)		3
Feed Final Score			
	C5 Feed Final Score (0-10)	**4.28**	**YELLOW**
	Critical?	**NO**	

Criterion 5: Feed – Meagre produced using whole fish – Egypt

5.1. Wild Fish Use			
	Feed parameters	**Score**	
	5.1a Fish In : Fish Out (FIFO)		
	Fishmeal inclusion level (%)	22.5	
	Fishmeal from by-products (%)	0	
	% FM	22.5	
	Fish oil inclusion level (%)	5	
	Fish oil from by-products (%)	0	
	% FO	5	
	Fishmeal yield (%)	22.5	

	Fish oil yield (%)	5	
	eFCR	9	
	FIFO fishmeal	9.00	
	FIFO fish oil	9.00	
	FIFO Score (0-10)	**0.00**	
	Critical?	YES	
	5.1b Sustainability of Source fisheries		
	Sustainability score	-10	
	Calculated sustainability adjustment	-18.00	
	Critical?	NO	
	F5.1 Wild Fish Use Score (0-10)	**0.00**	
	Critical?	Yes	
5.2 Net protein Gain or Loss			
	Protein INPUTS		
	Protein content of feed (%)	18	
	eFCR	9	
	Feed protein from fishmeal (%)		
	Feed protein from EDIBLE sources (%)	100.00	
	Feed protein from NON-EDIBLE sources (%)	0.00	
	Protein OUTPUTS		
	Protein content of whole harvested fish (%)	20.1	
	Edible yield of harvested fish (%)	100	
	Use of non-edible by-products from harvested fish (%)	0	
	Total protein input kg/100kg fish	162	
	Edible protein IN kg/100kg fish	162.00	
	Utilized protein OUT kg/100kg fish	20.10	
	Net protein gain or loss (%)	-87.59	
	Critical?	NO	
	F5.2 Net protein Score (0-10)	**1**	
5.3. Feed Footprint			
	5.3a Ocean Area appropriated per ton of seafood		
	Inclusion level of aquatic feed ingredients (%)		27.5
	eFCR		9
	Carbon required for aquatic feed ingredients (ton C/ton fish)		*69.7*
	Ocean productivity (C) for continental shelf areas (ton C/ha)		*2.68*
	Ocean area appropriated (ha/ton fish)		64.37

	5.3b Land area appropriated per ton of seafood		
	Inclusion level of crop feed ingredients (%)		0
	Inclusion level of land animal products (%)		0
	Conversion ratio of crop ingedients to land animal products		*2.88*
	eFCR		9
	Average yield of major feed ingredient crops (t/ha)		*2.64*
	Land area appropriated (ha per ton of fish)		0.00
	Total area (Ocean + Land Area) (ha)		64.37
	F5.3 Feed Footprint Score (0-10)		0
Feed Final Score			
	C5 Feed Final Score (0-10)	**0.00**	**RED**
	Critical?	**YES**	

Criterion 6: Escapes – EU & Turkey

6.1a System escape Risk (0-10)	1	
6.1a Adjustment for recaptures (0-10)	0	
6.1a Escape Risk Score (0-10)	**1**	
6.2. Competitive and genetic interactions score (0-10)	**3**	
C6 Escapes Final Score (0-10)	**2**	**RED**
Critical?	**NO**	

Criterion 6: Escapes – Egypt

6.1a System escape Risk (0-10)	0	
6.1a Adjustment for recaptures (0-10)	0	
6.1a Escape Risk Score (0-10)	**0**	
6.2. Competitive and genetic interactions score (0-10)	**9**	
C6 Escapes Final Score (0-10)	**5**	**YELLOW**
Critical?	**NO**	

Criterion 7: Diseases – EU & Turkey

Disease Evidence-based assessment (0-10)		

Disease Risk-based assessment (0-10)	4	
C7 Disease Final Score (0-10)	**4**	**YELLOW**
Critical?	NO	

Criterion 7: Diseases – Egypt

Disease Evidence-based assessment (0-10)		
Disease Risk-based assessment (0-10)	2	
C7 Disease Final Score (0-10)	**2**	**RED**
Critical?	NO	

Criterion 8X: Source of Stock – EU & Turkey

C8X Source of stock score (0-10)	0	
C8 Source of stock Final Score (0-10)	**0**	**GREEN**
Critical?	NO	

Criterion 8X: Source of Stock – Egypt

C8X Source of stock score (0-10)	-8	
C8 Source of stock Final Score (0-10)	**-8**	**RED**
Critical?	NO	

Criterion 9X: Wildlife and predator mortalities – EU & Turkey

C9X Wildlife and Predator Score (0-10)	**-2**	
C9X Wildlife and Predator Final Score (0-10)	**-2**	**GREEN**
Critical?	NO	

Criterion 9X: Wildlife and predator mortalities – Egypt

C9X Wildlife and Predator Score (0-10)	**-6**	
C9X Wildlife and Predator Final Score (0-10)	**-6**	**YELLOW**

Critical?	NO	

Criterion 10X: Escape of secondary species – EU & Turkey

F10Xa live animal shipments score (0-10)	10.00	
F10Xb Biosecurity of source/destination score (0-10)	10.00	
C10X Escape of unintentionally introduced species Final Score (0-10)	**0.00**	**GREEN**
Critical?	n/a	

Criterion 10X: Escape of secondary species – Egypt

F10Xa live animal shipments score (0-10)	10.00	
F10Xb Biosecurity of source/destination score (0-10)	10.00	
C10X Escape of unintentionally introduced species Final Score (0-10)	**0.00**	**GREEN**
Critical?	n/a	