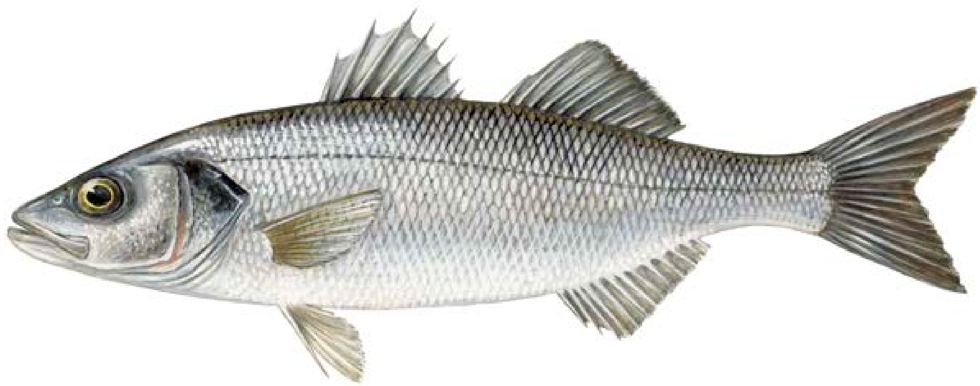
European Sea Bass, Gilthead Seabream

Dicentrarchus labrax, Sparus aurata



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Mediterranean Sea

Marine Net Pens

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Disclaimer

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 Report. Each report 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." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, 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 Seafood Reports 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 Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

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 must possess to be considered sustainable by the Seafood Watch program:

Seafood Watch will:

- Support data transparency and therefore aquaculture producers or industries that make information and data on production practices and their impacts available to relevant stakeholders.
- Promote aquaculture production that minimizes or avoids the 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 beyond the immediate vicinity of the farm.
- Promote aquaculture production at locations, scales and intensities that cumulatively maintain the functionality of ecologically valuable habitats without unreasonably penalizing historic habitat damage.
- Promote aquaculture production that by design, management or regulation avoids the use and discharge of chemicals toxic to aquatic life, and/or effectively controls the frequency, risk of environmental impact and risk to human health of their use.
- Within the typically limited data availability, use understandable quantitative and relative indicators to recognize the global impacts of feed production and the efficiency of conversion of feed ingredients to farmed seafood.
- Promote aquaculture operations that pose no substantial risk of deleterious effects to wild fish or shellfish populations through competition, habitat damage, genetic introgression, hybridization, spawning disruption, changes in trophic structure or other impacts associated with the escape of farmed fish or other unintentionally introduced species.
- Promote aquaculture operations that pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites.
- Promote the use of eggs, larvae, or juvenile fish produced in hatcheries using domesticated broodstocks thereby avoiding the need for wild capture.

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

- Recognize that energy use varies greatly among different production systems and can be a major impact category for some aquaculture operations, and also recognize that improving practices for some criteria may lead to more energy-intensive production systems (e.g. promoting more energy-intensive closed recirculation systems).

Once a score and rank has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ranks 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 Recommendation

European Sea Bass (*Dicentrarchus labrax*) & Gilthead Seabream (*Sparus aurata*)
Mediterranean Sea
Marine Net Pens

Criterion	Score (0-10)	Rank	Critical?
C1 Data	6.11	YELLOW	
C2 Effluent	6.00	YELLOW	NO
C3 Habitat	5.20	YELLOW	NO
C4 Chemicals	0.00	RED	NO
C5 Feed	4.05	YELLOW	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	4.00	YELLOW	NO
C8 Source	9.00	GREEN	
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Introduced species escape	0.00	GREEN	
Total	**36.36**		
Final score	**4.55**		

OVERALL RANKING

Final Score	4.55
Initial rank	YELLOW
Red criteria	1
Interim rank	YELLOW
Critical Criteria?	NO

FINAL RANK
YELLOW

Scoring note – scores range from zero to ten where zero indicates very poor performance and ten indicates the aquaculture operations have no significant impact.

Summary
The final numerical score for European sea bass and gilthead seabream farmed in the Mediterranean Sea is 4.55, which is in the yellow range. With one red criterion (chemical use) and no critical criteria, the final recommendation is “Yellow—Good Alternative.”

Executive Summary

Dicentrarchus labrax (European sea bass) and *Sparus aurata* (gilthead seabream) are both carnivorous marine finfish that have similar biologies and life histories, and are often cultured together at the same farming site. Therefore, this report covers both species in the assessment and recommendation.

The culture of sea bass and seabream is an important production sector in the Mediterranean Sea, and these species combined represent the largest volume of aquaculture production in the region (134,978 tons of European sea bass and 138,694 tons of gilthead seabream were produced in the Mediterranean Sea in 2012). This Seafood Watch assessment involves a number of different criteria covering impacts associated with effluent, habitats, chemical use, feed production, escapes, disease, the source stock, wildlife and predator interactions, introduction of non-native organisms (other than the farmed species), and general data availability.

The overall data availability and quality on sea bass/seabream aquaculture in the Mediterranean are moderate, with large volumes of data available for a number of criteria and relatively few data available for others. In general, a large volume of peer-reviewed scientific literature and government reports was available to inform this assessment. Production statistics are available from international organizations such as the United Nations Food and Agricultural Organization (FAO) and regional industry bodies such as the Federation of European Aquaculture Producers. Topics such as effluent and habitat impacts, diseases, and source of stock have been thoroughly researched and widely published by the scientific community. Data on impacts such as wildlife interactions and chemical use are not as readily available, and the industry would benefit from further research and increased transparency in these areas. Personal communications with academics and industry experts also provided a significant amount of information to inform this assessment, most notably in the areas of feed formulations and marine resource utilization. The numerical score for Criterion 1: Data is 6.11 out of 10.

Net pen production systems allow both particulate and dissolved effluents from aquaculture sites to flow untreated directly into the surrounding environment. Though these effluents may be detected downstream of Mediterranean sea bass/seabream culture sites, the impacts of these effluents are shown to be minor, with the majority of impacts occurring within the localized footprint of the farm. Because data show no evidence that discharges cause or contribute to cumulative impacts beyond the immediate vicinity of the farm, the numerical score for Criterion 2: Effluents is 6.00 out of 10.

Sea bass/seabream aquaculture in the Mediterranean results in moderate habitat impacts within the immediate footprint of the farm, mostly due to the inherently open nature of net pen production systems. Strong regulation and strict monitoring and enforcement mitigate many of these habitat impacts, resulting in a moderate score (5.20 out of 10) for Criterion 3: Habitat.

Though there has been significant development of vaccines and their application in recent years, diseases in sea bass/seabream aquaculture can and do occur, resulting in the need to treat fish with medicines. Select examples exist of production without the use of chemicals, but three broad-spectrum antibiotics (oxytetracycline, florfenicol, and flumequine) are the principal chemicals currently used in sea bass/seabream aquaculture in the Mediterranean. These chemicals are legal for use in animal husbandry within the countries operating sea bass/seabream farms; however, it should be noted that flumequine is not legal for use in aquaculture in the United States. In the Mediterranean, these compounds must be prescribed by a licensed veterinarian and are administered through medicated feed with strict regulatory oversight. Although there is every indication that chemical use in sea bass/seabream aquaculture is done responsibly, no specific antibiotic volumes or frequencies were made available for this report. The low score for this criterion is driven by the use of chemicals listed by the World Health Organization as being “Highly Important” (oxytetracycline and florfenicol) and “Critically Important” (flumequine) to human health, indicating their importance in human medicine. Because historical and current chemical information and frequencies were not available, the Seafood Watch criteria dictate a precautionary score of 0 out of 10 based on the use of “Critically Important” chemicals in unknown quantities.

Direct input from academics, feed manufacturers, and farm managers shows current fishmeal and fish oil inclusion rates of 21% and 10% respectively, and a feed conversion ratio (FCR) of 2.0. The majority of marine feed ingredients are sourced either from sustainable fisheries or processing byproducts. However, based on protein inputs and outputs, a 67.2% net loss of protein is experienced during production. Totals of 16.12 hectares of ocean area and 0.57 hectares of land area were calculated to be required to produce the marine and terrestrial feed ingredients necessary to produce one ton of farmed fish. The numerical score for Criterion 5: Feed is 4.05 out of 10.

The open nature of net pens indicates that there is a high inherent risk of escape associated with these production systems. Both sea bass and seabream are native to the Mediterranean; however, the majority of fish are sourced from domesticated, hatchery-reared broodstock that have experienced artificial selection for favorable production traits over several generations. Despite this domestication, there is no indication that escapes have had negative genetic effects on wild populations. The numerical score for Criterion 6: Escapes is 4.00 out of 10, driven principally by an appropriate precautionary approach toward open net pens.

Several diseases associated with sea bass/seabream farms have been shown to have environmental and economic impacts, but there is no evidence of transmission of diseases from farmed fish to wild populations. Although the open nature of net pens represents inherently low biosecurity of the system and allows for any disease agents to transfer freely into and out of the farm site, the increased use of vaccines has greatly reduced the frequency and magnitude of disease outbreaks in recent years. The score for Criterion 7: Disease is 4.00 out of 10, driven principally by precaution over marine open net pens.

The majority of sea bass and seabream juveniles are produced from hatchery-reared broodstock. Though quite small numbers of wild-caught broodstock may be utilized, these numbers are not significant enough to have population-level effects on wild stocks, and only serve to add genetic diversity to selectively bred lines. Thus the Mediterranean sea bass/seabream industry can be said to be >90% independent of wild stocks, and Criterion 8: Source of Stock receives a numerical score of 9.00 out of 10.

Even though sea bass/seabream aquaculture operations attract a variety of predators and wildlife (most notably birds but also fishes and mammals), mortalities are limited to exceptional cases, and no incidents of mortalities of endangered species have occurred. So Exceptional Criterion 9X scores −2.00 out of −10.

Despite live-animal transport across national borders (e.g., from a hatchery in Italy to a marine net pen site in Greece), all sea bass/seabream farming takes place in the Mediterranean Sea, which is considered an ecologically homogenous water body for the purposes of this assessment. Therefore, no trans-water body shipments occur and no penalty is assigned for Exceptional Criterion 10X.

The final numerical score for sea bass/seabream farmed in the Mediterranean is 4.55, and with only one red criterion, the final ranking is “Yellow—Good Alternative.”

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Introduction

Scope of the analysis and ensuing recommendation

Species: European sea bass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*)
Geographic coverage: Mediterranean Sea
Production Methods: Marine net pens

Species Overview

European sea bass and gilthead seabream are both carnivorous marine finfish that have similar biologies and life histories. Thus, they are cultured in similar production systems, often co-existing on farm sites. These species were two of the first to be cultured on a commercial scale in Europe. They are native to the Mediterranean Sea, and these species combined currently represent the largest volume of aquaculture production in the Mediterranean. Leading producers are Greece and Turkey, followed by Spain, Egypt, and Italy.

It is estimated that 90% of commercial production of sea bass and seabream in the Mediterranean Sea occurs in marine net pens (pers. comm., Barazi-Yeroulanos, 2013). Approximately 10% of Mediterranean production occurs in land-based tanks and raceways, as well as low-density production in lagoons and ponds (known as “valliculture”) (pers. comm., Barazi-Yeroulanos, 2013). Though it is not known what percentage of U.S. imports are produced in systems other than marine net pens, the scope of this reports focuses on commercial-scale net pen farming of sea bass and seabream in all the Mediterranean countries.

Production system

D. labrax and *S. aurata* have similar biologies and life histories, so they are often grown within the same farming site. Both species are spawned in on-land hatcheries utilizing principally hatchery-raised broodstock. *D. labrax* juveniles are stocked in ongrowing systems when they reach a weight of 1.5–2.5 grams (g), and *S. aurata* are stocked when they reach a weight of 5 g (FAO, 2014). 90% of ongrowing occurs in marine net cages, while 10% utilizes land-based tanks or natural lagoons (known as “valliculture”) (pers. comm., Barazi-Yeroulanos, 2013). The production cycle typically lasts 16–18 months while the fish are grown to a market size of 400–600 g (FAO, 2014).

Production Statistics

According to the Federation of European Aquaculture Producers, 134,978 tons (t) of European sea bass and 138,694 t of gilthead seabream were produced in the Mediterranean Sea in 2012 (FEAP, 2013). Top producing nations include Greece, Turkey, and Spain. Figure 1 below provides a species-specific production volume breakdown for several of the major production countries.

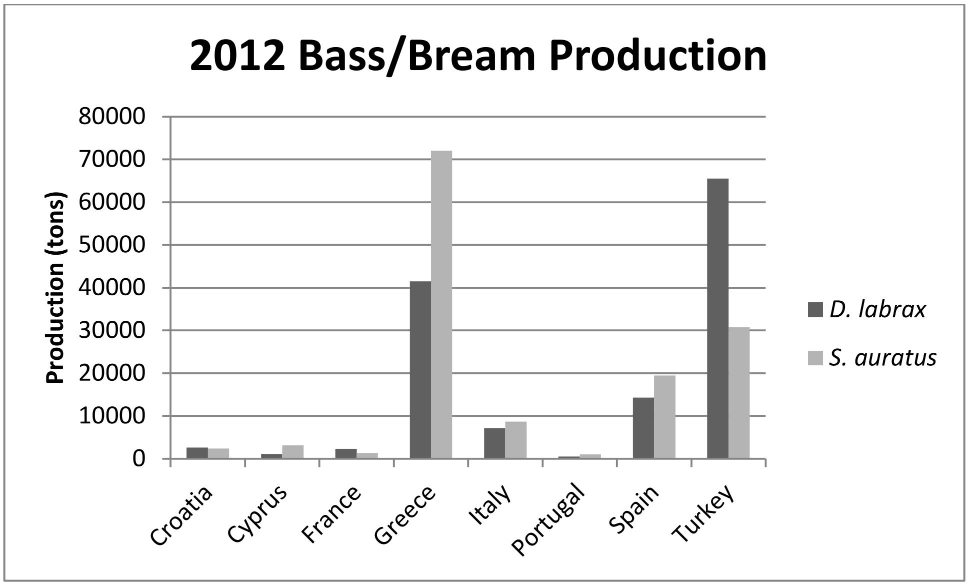

Figure 1. 2012 production volumes (tons) of *D. labrax* and *S. aurata* in major production countries

Import/Export Sources and Statistics

According to the United States National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) database, a total of 7,154,321 kilograms (kg) (≈7,154.3 metric tons) of "sea bass" was imported by the United States in 2013 (NOAA, 2014). Though the NMFS database specifies *Dicentrarchus* spp. (the genus to which European sea bass belongs) as the species, there is no further indication if this product is *D. labrax* specifically or some other member of the sea bass genus. Additionally, there is no indication whether this sea bass is from farmed or wild sources. The top five countries and their U.S.-imported volumes of sea bass are presented in Table 1 below.

Table 1. Volumes of "sea bass" imported by the United States in 2013 (NMFS, 2014)

Country	Volume Imported by the United States (kg)
Greece	2,171,914
South Korea	808,771
Turkey	772,778
Falkland Islands	732,161
France	380,678

Because several of these countries (e.g., South Korea, the Falkland Islands, and France) do not have significant aquaculture production of sea bass, it is expected that either a) rather than being produced in these countries, the imported sea bass was processed there before being imported by the United States; or b) the species produced in these countries and subsequently imported by the U.S. was not *D. labrax* but another species of "sea bass."

According to the same U.S. NMFS database, a total of 433,491 kg (≈433.5 mt) of "seabream" was imported by the United States in 2013 (NOAA, 2014). Though the NMFS database specifies *Sparidae* spp. (the genus to which gilthead seabream belongs) as the species, there is no further indication if this product is *S. aurata* specifically or some other member of the seabream genus. Additionally, there is no indication whether this seabream is from farmed or wild sources. The top five countries and their U.S.-imported volumes of seabream are presented in Table 2.

Table 2. Volumes of "seabream" imported by the United States in 2013 (NMFS, 2014)

Country	Volume Imported by the United States (kg)
Greece	266,401
Cyprus	68,728
Turkey	52,436
Japan	30,882
Spain	5,703

Because Japan does not have significant aquaculture production of seabream, it is expected that either a) rather than being produced in Japan, the imported seabream was processed there before being imported by the United States; or b) the species produced and subsequently imported by the U.S. was not *S. aurata*.

The U.S. exported 498,284 kg of sea bass (*Dicentrarchus* spp.) and 252,298 kg of seabream (*Sparidae* spp.) in 2013 (NOAA 2014). Because no significant aquaculture production of either *D. labrax* or *S. aurata* occurs in the United States, it is expected that these volumes were produced elsewhere and processed in the United States before being exported.

Common and Market Names

Table 3. Common and market names for the two species under assessment

Scientific Name	*Dicentrarchus labrax*	*Sparus aurata*
Common Name	European sea bass	Gilthead seabream
United States	European sea bass/*branzino*/*branzini*	Giltheaded seabream
United Kingdom	Mediterranean sea bass/*branzino*/*branzini*	Silver seabream
Spain	*Lubina*	*Dorada*
France	*Loup de mer*	*Dorada royale*
Italy	*Spigola*	*Orata*
Turkey	*Levrek*	*Cipura*

"Sea bass" is a common market name for a variety of fish species, so consumers selecting sea bass should be aware of the issues of seafood fraud and traceability (NOAA, 2013). The "FishWatch" program maintained by the National Oceanic and Atmospheric Administration (NOAA) is an excellent source of information for consumers interested in learning more about seafood fraud (www.fishwatch.gov).

Product Forms

Sea bass and seabream are usually sold as whole fish, both for retail sale (supermarkets) and for restaurants and catering services. Some filleted forms are available, but because most harvested fish are relatively small (400–600 g) and there is competition from other filleted species (salmon, trout, and flatfishes), producers of sea bass and seabream work to take advantage of market conditions by delivering whole fish (Stirling University 2004).

Analysis

Scoring guide

- With the exception of the exceptional factors (3.3x and 6.2X), all scores result in a zero to ten final score for each criterion and the overall final rank. A zero score indicates lowest performance, while a score of ten indicates highest performance. In contrast, the two exceptional factors result in negative scores from zero to minus ten, and in these cases zero indicates no negative impact.
- The full Seafood Watch Aquaculture Criteria to which the following scores relate are available here
- The full data values and scoring calculations are available in Appendix 1

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: robust and up-to-date information on production practices and their impacts is available to relevant stakeholders.*

Criterion 1 Summary

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	7.5	7.5
Effluent	Yes	7.5	7.5
Locations/habitats	Yes	7.5	7.5
Predators and wildlife	Yes	2.5	2.5
Chemical use	Yes	2.5	2.5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	7.5	7.5
Source of stock	Yes	10	10
Other – (e.g. GHG emissions)	No	Not relevant	n/a
Total			**55**

C1 Data Final Score	**6.11**	**YELLOW**

Brief Summary

The overall data availability and quality on sea bass/seabream aquaculture in the Mediterranean are moderate, with large volumes of data available for a number of criteria and relatively few data available for others. In general, a large volume of peer-reviewed scientific literature and government reports was available to inform this assessment. Production statistics are available from international organizations such as the United Nations Food and Agricultural Organization (FAO) and regional industry bodies such as the Federation of European Aquaculture Producers. Topics such as effluent and habitat impacts, diseases, and source of stock have been thoroughly researched and widely published by the scientific community. Data on impacts such as wildlife interactions and chemical use are not as readily available, and the industry would benefit from further research and increased transparency in these areas. Personal communications with academics and industry experts also provided a significant amount of information to inform this assessment, most notably in the areas of feed formulations and marine resource utilization. The numerical score for Criterion 1: Data is 6.11 out of 10.

Justification of Ranking

General industry and production statistics for both species are available from international agencies (e.g., the United Nations Food and Agricultural Organization) as well as regional industry bodies (e.g., the Federation of European Aquaculture Producers); however, the total number and specific location of all farming sites in the Mediterranean could not be ascertained.

Although no farm-specific effluent monitoring data were available, a relatively large volume of scientific literature exists documenting water quality testing, impact monitoring, and the regulatory control and enforcement of the effluent impacts from net pen sea bass/seabream culture. Notable examples include (Maldonado et al. 2005) (Karakassis et al. 2005) (Najdek et al. 2007) (Holmer et al. 2008) (Sanz-Lazaro et al. 2011). There are also numerous scientific studies that focus on habitat impacts, such as habitat types, history of habitat conversion, habitat monitoring, and habitat regulatory control and enforcement. Studies especially valuable to this assessment include (Delgado et al. 1997) (Holmer et al. 2007) (Mirto et al. 2010) (Puhr and Pikelj 2012).

Although it is known that sea bass and seabream escape from Mediterranean farms, the extent and numbers are not well known (Toledo Guedes et al. 2009). The information available on escapes focuses on recapture and survival rates, e.g., (Dempster et al. 2002) (Arechavala-Lopez et al. 2011) (Arechavala-Lopez et al. 2012), as well as genetic and ecosystem impacts of escapes, e.g., (Haffray et al. 2007) (Sola et al. 2007) (Volkaert et al. 2008). Though the industry does undertake international shipments of live animals, all production occurs within the Mediterranean Sea, which is considered a homogenous body of water for the purposes of this assessment. Because it is considered that there are no trans-waterbody shipments of live animals, the escape of unintentionally introduced species is not applicable to this evaluation.

Diseases in Mediterranean sea bass/seabream culture have been thoroughly studied, and cover common disease outbreaks, mortalities, and pathogen treatments. Studies significant to this assessment include (Castric et al. 2001) (Paladini et al. 2009) (Fernandez-Jover 2010). Additionally, as an established commercial industry with operations that have relied on hatchery-produced fish for several decades, sea bass/seabream culture has no dependence on wild fisheries for broodstock, larvae, or juveniles; this was corroborated by farm managers, academics, and industry bodies.

Some criteria (e.g., chemicals and predator/wildlife mortalities) have less publicly available data, so published information for these criteria is limited. For example, the chemicals used in sea bass/seabream aquaculture are known, but there is no information available on frequencies, dosages, and the impact of discharges. Also, there are a few studies examining predator and wildlife mortality events, yet there is no information available on potential population impacts of these mortalities.

Personal communications with academics and industry experts were effective at bridging data gaps and provided a significant amount of data with respect to current aquaculture operations in the Mediterranean. Information on current chemical and vaccine use was obtained through direct personal communications with representatives from VetCare (Greece), Aquark (Greece), and the Producers Association of Marine Aquaculture (Spain), all of whom have extensive fish pathology and veterinary experience in the Mediterranean region.

For information pertaining to feed, the proprietary nature of feed formulations indicates that published information is limited; input regarding feed ingredients and sourcing, Feed Conversion Ratios, inclusion rates of fishmeal and fish oil (including by-products), inclusion of vegetable or crop meals and oils, and land animal products and by-products was gathered from direct personal communications. Data to inform the marine resource utilization calculations in this assessment were provided by several researchers at the University of Thessaly (Greece) as well as representatives at Aquark (Greece). These data were independently corroborated by industry and feed manufacturing representatives, including experts at Nireus Aquaculture S.A., Kefalonia Fisheries S.A., and Bio-Mar Hellenic S.A.

Overall Criterion 1: Data receives a final numerical score of 6.11 out of 10.

Criterion 2: Effluents

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: aquaculture operations 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 beyond the immediate vicinity of the farm.*

Criterion 2 Summary

Effluent Evidence-Based Assessment

C2 Effluent Final Score	**6.00**	**YELLOW**

Brief Summary

Net pen production systems allow both particulate and dissolved effluents from aquaculture sites to flow untreated directly into the surrounding environment. Though these effluents may be detected downstream of Mediterranean sea bass/seabream culture sites, the impacts of these effluents are shown to be minor, with the majority of impacts occurring within the localized footprint of the farm. Because data show no evidence that discharges cause or contribute to cumulative impacts beyond the immediate vicinity of the farm, the numerical score for Criterion 2: Effluents is 6 out of 10.

Justification of Ranking

This effluent criterion considers the impacts beyond the immediate farm site, or outside a regulatory Allowable Zone of Effect (AZE). The Habitat Criterion (Criterion 3) considers the impacts on the area within the farm boundary or AZE (primarily from settling solid wastes, in the case of net pen sea bass/seabream culture). There is considered to be sufficient monitoring data and academic study on sea bass/seabream farming in the Mediterranean to use the Seafood Watch Evidence-Based Assessment option for the Effluent Criterion; these studies are discussed in detail below.

Particulate wastes in the forms of feces and uneaten feed from marine net pens can alter the quantity and biochemical composition of sediment organic matter, which in turn can alter benthic communities both underneath the farm site and in the surrounding area. (For a general description, *see* (Black et al. 2008); for an examination specific to the Mediterranean region, *see* (Holmer et al. 2008a) (Mirto et al. 2010).) For example, a 2011 study conducted at a sea bass and seabream farm in Spain found that total phosphorus (TP) and redox potential values in the sediment were significantly different at 600 m and 0 m from the fish pen, and followed a decreasing and increasing trend, respectively (Sanz-Lazaro et al. 2011). The authors attribute the differences to the presence and operation of the fish farm, which is consistent with the findings of earlier studies (Karakassis et al. 1998) (Edgar et al. 2010).

The results of these studies indicate that particulate effluents from sea bass and seabream pen aquaculture operations can be detected outside the immediate vicinity of the farm site. But several additional studies show that, although particulates can be detected, the manifested environmental effects of these particles are localized to the immediate footprint of the operation. For example, (Tomassetti et al. 2009) demonstrates disturbances of benthic macrofaunal assemblages under net pens (discussed further in Criterion 3: Habitat) but no effects in the area more than 25 m from the pen. Furthermore, (Maldonado et al. 2005) (Najdek et al. 2007) (Mirto et al. 2010) all demonstrate a localized effect of fish farming waste: it is confined to the area directly underneath the pens. These findings indicate that even though particulate effluents from sea bass and seabream farms cause changes in species diversity and community structure that are associated with excessive nutrient inputs, these impacts appear to be localized to the immediate vicinity of the farm (considered in Criterion 3: Habitat).

The impacts of soluble effluents on the water column as a result of net pen aquaculture operations in the Mediterranean are known: clear patterns of nutrient enrichment of the water column around fish pens are evident in sources such as (Sara 2007) (Dempster and Sanchez-Jerez 2008) (Sanz-Lazaro et al. 2011). Also, (Modica et al. 2006) demonstrates a biochemically detectable enrichment of the water column up to 300 m from the pens, which is outside the normal farm boundaries; however, the study also notes that this organic enrichment is below the minimum threshold necessary to cause undesirable biological consequences.

As further noted (Sara et al. 2011), the distance at which dissolved nutrients can be detected is based principally on the hydrodynamic conditions of the site, with enclosed bays exhibiting less dilution and subsequently more soluble enrichment than exposed sites. As clearly shown in the literature (most notably (Aguado-Gimenez et al. 2007) (Diaz-Almela et al. 2008) (Tomassetti et al. 2009)), increased water flow and greater water depths (conditions found at more exposed sites) result in improved culture conditions within the pens and decreased effluent impacts (particulate and soluble) from the dilution and faster assimilation of nutrients into the environment. Industry-wide trends in the Mediterranean have exhibited a shift toward these more exposed sites, and this trend is expected to continue (Holmer 2010), (pers. comm., Barazi-Yeroulanos, 2013), (pers. comm., Karapanagiotidis, 2013).

Much of the coastal zone of the Mediterranean is inhabited by the seagrass *Posidonia oceanica*, which is highly vulnerable to marine aquaculture activities as evidenced by severe impacts to *P. oceanica* meadows directly below fish farms (Holmer et al. 2008a). Though several additional studies demonstrate this loss due to aquaculture (Maldonado et al. 2005) (Najdek et al. 2007), it should be noted that as of 2006 siting and licensing regulations in the European Union, the region where the majority of sea bass and seabream production occurs, specifically prohibit the establishment of aquaculture sites above *P. oceanica* meadows (European Union E.C. 1967/2006). Furthermore, prior to the issuance of a new or renewed license, regulatory authorities require third-party (e.g., university or public research institute) verification that there is no *P. oceanica* in the area where the farm will be operating, including outside the farm boundary in an allowable zone of effect (pers. comm., Papaharissis, 2013).

In conclusion, though the effluents from sea bass and seabream farms are able to be detected downstream of the farm, data show the impacts of these effluents are localized to the immediate vicinity of the operation. Additionally, the evidence suggests that discharges do not cause, nor contribute to, cumulative local or regional impacts beyond the immediate vicinity of the farm. So the final numerical score for Criterion 2: Effluent is 6.00 out of 10.

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: aquaculture operations are located at sites, scales and intensities that cumulatively maintain the functionality of ecologically valuable habitats.*

Criterion 3 Summary

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		4.00	
F3.2a Content of habitat regulations	4.00		
F3.2b Enforcement of habitat regulations	4.75		
F3.2 Regulatory or management effectiveness score		7.60	
C3 Habitat Final Score		**5.20**	**YELLOW**
Critical?	NO		

Brief Summary

Sea bass/seabream aquaculture in the Mediterranean results in moderate habitat impacts within the immediate footprint of the farm, mostly due to the inherently open nature of net pen production systems. Strong regulation and strict monitoring and enforcement mitigate many of these habitat impacts, resulting in a moderate score (5.20 out of 10) for Criterion 3: Habitat.

Justification of Ranking

Factor 3.1. Habitat conversion and function

As a result of feces and uneaten food, intensive fish farming activities generate a localized gradient of organic enrichment in the underlying and adjacent sediments (Black et al. 2008). These nutrient inputs can influence the abundance and diversity of benthic faunal communities; in the area under the pens or within the regulatory AZE, the impacts are now relatively well understood and may be profound (*see* (Black et al. 2008) for a review of these impacts).

Several studies have examined the specific impacts of sea bass/seabream pen culture on benthic faunal communities directly below pens situated in both near-shore coastal waters and at more exposed sites. The results of near-shore studies (Maldonado et al. 2005) (Najdek et al. 2007) (Mirto et al. 2010) provide evidence that particulate effluents and organic wastes stemming from the pens negatively impact functionality of the benthic ecosystem directly below the pens. Studies at exposed sites (Aguado-Gimenez et al. 2007) (Diaz-Almela et al. 2008) (Tomasetti et al. 2009) demonstrate less benthic impact compared to coastal farms, due to increased water flow and subsequent dilution and dispersal of particulate and soluble waste products. Another study (Holmer 2010) found that the dispersal of dissolved and particulate nutrients reduces the intensity of environmental interactions at farming sites and increases the assimilative capacity of the ecosystem; these results concur with those of (Maldonado 2005) and (Matijevik et al. 2009). It should be noted that industry-wide trends in the Mediterranean have shifted toward more-exposed sites, where increased water flow and greater water depths provide improved culture conditions within the pens and decreased impacts on habitats in the immediate area of the farm (Holmer 2010) (pers. comm., Barazi-Yeroulanos 2013) (pers. comm., Karapanagiotidis 2013).

Heavy metals such as zinc, copper, iron, cadmium, lead, and nickel have been recorded in the water column and sediment beneath sea bass and seabream net pen sites in the eastern Mediterranean (Belias et al. 2003) (Basaran et al. 2010). Also, (Sapotka et al. 2008) demonstrates that the source of these metals is enriched formulated diets used in finfish production; however, the authors conclude that metal concentrations in the sediments have yet to reach dangerous levels for the aquatic environment. This conclusion is also supported by the work of (Basaran et al. 2010), which studied and described how the ecosystem surrounding sea bass/seabream farms in Turkey was able to assimilate both organic and inorganic nutrients with no significant impacts.

The Mediterranean coastal zone has excellent ecological conditions for benthic vegetation; the seagrass *Posidonia oceanica* is the dominant species, covering from $2.5–5 \times 10^{10}$ m^2 of the coastal zone to a depth of 45 m (Holmer et al. 2007b). Seagrasses play major ecological roles in the coastal zone, including preventing coastal erosion, increasing coastal biodiversity, oxygenating the water and sediments, increasing water transparency, and accumulating carbon (Holmer et al. 2007).

Individual *P. oceanica* beds have been shown to be highly vulnerable to marine aquaculture activities (Delgado et al. 1997) (Delgado et al. 1999). Historically, the shading of sunlight by pens and other farm equipment, the deterioration of sediment quality, and the sedimentation of organic matter emanating from fish pens have all contributed to reductions of *P. oceanica* populations directly beneath fish farms (Ruiz et al. 2001) (Cancemi et al. 2003) (Holmer et al. 2007). But as of 2006, siting and licensing regulations in the European Union specifically prohibit the establishment of fish farms above *P. oceanica* meadows (European Union E.C. 1967/2006). And prior to the issuance of a new or renewed license, regulatory authorities require third-party (e.g., university or public research institute) verification that there is no *P. oceanica* in the area where the farm will be operating (pers. comm., Papaharissis, 2013).

Sea bass/seabream aquaculture has occurred in the Mediterranean for more than 20 years, while a significant amount of environmental monitoring and study has been conducted. It has been widely corroborated that wastes from sea bass/seabream pens affect the seabed within the immediate vicinity of the farm. Although new legislation prevents some historic impacts from occurring any longer (e.g., loss of *P. oceanica* meadows), the open nature of net pens inherently affects the habitat within the footprint of the farm. The score for Factor 3.1 is 4 out of 10, indicating moderate habitat impacts in high value coastal habitats.

Factor 3.2. Habitat and farm siting management effectiveness (appropriate to the scale of the industry)

The principal sea bass/seabream production countries are Greece, Turkey, Spain, and Italy, among other European nations. Therefore, there are two distinct regulatory regions (Europe and the Middle East); the inherent diversity of country-specific management regulations and protocols creates a challenging situation from an assessor's perspective. However, there are many European-wide regulations governing aquaculture in all European Union countries, and Turkey has enacted comparable legislation with respect to marine pen culture of finfish. Since Greece and Turkey are the largest producers of sea bass/seabream, the majority of the analysis below on habitat regulations focuses on these two countries.

Through the approval of Directive 2000/60/CE, dated October 23, 2000, the European Union provided a framework for the protection of inland surface waters, transition waters, coastal waters, and subsurface waters (FAO, 2014). All European countries must comply with this regulation; however, there are also additional specific legal requirements ensuring habitat protection in the Mediterranean.

For example, the siting and licensing procedures for new operations are all based on ecological principles and the protection of surrounding habitats, and include requirements for Environmental Impact Assessments (EIAs). In Greece, Law No. 1650/1986 for the Protection of the Environment requires EIAs for all new licenses as well as for expansions or renovations of existing facilities (FAO 2014). In Turkey, Article 8 of Aquaculture Regulation No. 25507 states that an aquaculture license may only be granted if it is pursuant to relevant provisions of the Regulation of Environmental Impact Assessment (EIA) No. 26939 (FAO, 2014). According to No. 26939, all fish farms are required to conduct an EIA except if the annual production is less than 30 mt/year (FAO, 2014).

In Greece, net pen aquaculture is regulated by Law No. 3199/9-12-2003 "Water protection and management—Conformation with the Directive (EC) No. 2000/60 of 23-10-2000," which categorizes all types of water sources and defines measures for monitoring and protection, as well as by Ministerial Decree No. 51/2-3-2007: "Establishment of measures and procedures for the integrated management and protection of water sources, in compliance with Directive No. 2000/60 of 23-10-2000 establishing a framework for Community action in the field of water policy" (FAO 2014). Similarly, in Turkey, the principal legislation concerning water quality and the discharge of wastewater is Fisheries Regulation No. 22223. Article 11 of this Regulation bans the discharge of any pollutants into marine and freshwater bodies used for fishery production that might harm fish well-being (FAO 2014). These legislations provide examples from the major sea bass/seabream-producing countries of the requirements that the industry's total size and relative concentration do not interfere with ecosystem functionality (FAO 2014), including protecting *P. oceanica* meadows from instances of localized habitat impacts from effluents (European Union E.C. 1967/2006).

With respect to the future growth of the industry, any coastal/enclosed sites where ecosystem impacts are shown to be greatest (Mirto et al*.* 2010) are not likely to be heavily expanded into, because the majority of appropriate sites are already in use or cannot be utilized by aquaculture operations due to conflicts over shared resources (pers. comm., Papaharissis, 2013) (FAO 2014). A trend has already been seen in the industry toward siting in more exposed conditions, where ecosystem impacts are of a smaller magnitude (Holmer 2010) (pers. comm., Barazi-Yeroulanos, 2013) (pers. comm., Karapanagiotidis, 2013), and it is expected that this trend will continue.

Habitats of high sensitivity are required to be avoided under the national legislations (FAO 2014). For example, in Greece, Sanitary Provision E1B/221/65 determines all the procedures intended for wastewater disposal and, to that end, Ministerial Decision No. 222916/17-9-1991 was issued to clarify the application of the Sanitary Provision terms on marine and land-based aquaculture farms. There is no evidence to suggest that any highly vulnerable or endangered wild populations are affected by the siting of sea bass/seabream farms. A thorough review of peer-reviewed literature yielded no requirements in any country's legislation for the restoration of important or critical habitats or ecosystem services.

Farm siting and licensing processes function in accordance with the legislation and management protocols outlined by each country (pers. comm., Papaharisis, 2012). Additionally, these permitting processes take into account other stakeholders within the specific region of the farm (FAO 2014). Permitting and licensing is transparent, with governing bodies including all relevant stakeholders in the application process (FAO 2014). Countries have shown strict enforcement regarding compliance with Environmental Impact Assessments, licensing procedures, ongoing environmental monitoring, and operations, with all companies being subjected to monthly and yearly monitoring and review by both national and regional authorities (pers. comm., Barazi-Yeroulanos, 2013).

It appears as if the restrictions and limitations set out in the control measures discussed above are being achieved. The consideration of total industry size, cumulative impacts, protection of surrounding environments, and enforcement of regulations is shown to be strong. Though there is a lack of requirements to rectify and restore ecosystem services lost as a result of industry activities, it is apparent that no significant losses are currently occurring. The final score for Factor 3.2 is calculated from a regulatory content score of 4.0 out of 5, and a regulatory enforcement score of 4.75 out of 5. The final habitat and farm siting management effectiveness score is 7.60 out of 10.

Criterion 3 – Habitat

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). The final numerical score for Criterion 3: Habitat is 5.20 out of 10, indicating that Mediterranean sea bass/seabream farming has moderate habitat concerns.

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: aquaculture operations by design, management or regulation avoid the discharge of chemicals toxic to aquatic life, and/or effectively control the frequency, risk of environmental impact and risk to human health of their use*

Criterion 4 Summary

Chemical Use parameters	Score	
C4 Chemical Use Score	**0.00**	
C4 Chemical Use Final Score	**0.00**	**RED**
Critical?	NO	

Brief Summary

Although there has been significant development of vaccines and their application in recent years, diseases in sea bass/seabream aquaculture can and do occur, resulting in the need to treat fish with medicines. Select examples exist of production without the use of chemicals, but three broad-spectrum antibiotics (oxytetracycline, florfenicol, and flumequine) are the principal chemicals currently used in sea bass/seabream aquaculture in the Mediterranean. These chemicals are legal for use in animal husbandry within the countries operating sea bass/seabream farms; however, it should be noted that flumequine is not legal for use in aquaculture in the United States. In the Mediterranean, these compounds must be prescribed by a licensed veterinarian and are administered through medicated feed with strict regulatory oversight. Though there is every indication that chemical use in sea bass/seabream aquaculture is done responsibly, no specific antibiotic volumes or frequencies were made available for this report. The low score for this criterion is driven by the use of chemicals listed by the World Health Organization as being "Highly Important" (oxytetracycline and florfenicol) and "Critically Important" (flumequine) to human health, indicating their importance in human medicine. Because historic and current chemical information and frequencies were not available, the Seafood Watch criteria dictate a precautionary score of 0 out of 10 based on the use of "Critically Important" chemicals in unknown quantities.

Justification of Ranking

Although chemicals can be utilized for a variety of purposes in aquaculture (*see* (Douet et al. 2009) for an overview), chemicals are used in sea bass/seabream production in the Mediterranean only for health management (i.e., no use as growth promoters or prophylaxis).

Vaccines have played a vital role in combating disease and reducing the amount of chemicals needed in recent years (Plumb and Hanson 2011) (pers. comm., Papaharisis, 2013) (pers. comm., Christofilogiannis, 2013) (pers. comm., Ojeda, 2014). Oxytetracycline, florfenicol, and flumequine are currently the most widely used chemicals in Mediterranean sea bass/seabream aquaculture. These compounds are broad-spectrum antibiotics and are used to combat a wide range of bacterial infections associated with livestock husbandry, including finfish culture.

The low score for this criterion is driven by the fact that these chemicals are listed as both “Highly Important” and “Critically Important” antimicrobials by the World Health Organization. These listings indicate the chemicals’ high value in human medicine, and the use of any chemical in the “Critically Important” group in any volume or frequency dictates a Chemical Use score of 0 out of 10 according to the Seafood Watch criteria.

These chemicals are licensed for use in marine aquaculture in the countries operating sea bass/seabream farms in the Mediterranean (Christofilogiannis 2002) (pers. comm., Papaharisis, 2013) (pers. comm., Ojeda, 2014). In sea bass/seabream aquaculture, these drugs are administered through medicated feed and must be prescribed by a licensed veterinarian; additionally, their administration is overseen by both National Drug Administrations and State Veterinary Services (Directives 2001/82/EC; 2004/28/EC).

The existing data, although relatively out of date, suggest that water and sediment drug levels beneath and around fish farms are unlikely to be adequate for causing toxicity effects on wildlife (Miglione et al. 1997) (Rigos and Troisi 2005). Oxytetracycline and flumequine are reported to have low toxicity for fish, lessening the risk toward non-target finfish species in the vicinity of the farm (Douet et al. 2009). The risk to other organisms has also been shown to be low: for example, the maximum reported concentration of flumequine (0.58 mg/kg^{-1}) in sediments in the vicinity of sea bass farms in Italy (Lalumera et al. 2004) is well below the effective concentration for 50% toxicity (EC_{50}) value for flumequine determined for brine shrimp (*Artemia* spp.) (Miglione et al. 1997).

In EU countries, both farm sites and harvested product are regularly audited by the relevant national veterinary authorities to ensure farmers’ compliance with regulations (Directives 2001/82/EC; 2004/28/EC). This strict legislation, coupled with regular audits, indicates that banned and illegal chemicals are likely not used in sea bass/seabream aquaculture in European countries.

One potential consequence of antibiotic use in aquaculture is the development of resistance in fish and human pathogens, which can reduce the drugs’ efficacy and therapeutic value (Grigorakis and Rigos 2011) (Laxminarayan et al. 2013). Select examples could be found in scientific literature that reported incidents of antibiotic-resistant bacterial populations in Mediterranean sediments (Chelosi et al. 2003) (Labella et al. 2013) and *D. labrax* tissue samples (Matyar 2007). But aquaculture and academic experts indicate that these compounds are utilized in a controlled and responsible manner according to the relevant regulatory and legislative limits of the country where the operation occurs (pers. comm., Papaharisis, 2012) (pers. comm., Karapanagiotidis, 2013) (pers. comm., Ojeda, 2014). Despite these assurances, the instances of antimicrobial resistance outlined above warrant a high concern and subsequently a precautionary low score for this criterion.

Although many drivers of antibiotic consumption are based in human medicine, antibiotic uses for disease treatment, growth promotion, and disease prevention in agriculture, aquaculture, and horticulture are also major contributing factors (Laximinaryan et al. 2012). Unnecessary antibiotic use in all sectors needs to be reduced, and the spread to the environment minimized (Laxminarayan et al. 2013). Therefore, the use of antibiotics highly important to human health in open net pen farms is a source of concern. However, as stated by (Miranda 2012), “[F]urther studies are necessary to understand how antibacterial resistance spreads among environmental microbiota and the ecological significance of the occurrence of multidrug-resistant bacteria in fish farm environments.”

There are several examples of producers in the Mediterranean that conduct sea bass/seabream aquaculture completely without the use of antibiotics (pers. comm., Barazi-Yeroulanos, 2013). However, production without the use of antibiotics seems to be an exception rather than an industry-wide trend, because less than 0.001% of total Mediterranean sea bass/seabream aquaculture has been confirmed to occur without the use of the discussed antibiotics. Though antibiotic-free production may serve as a model for the industry to reduce chemical use, current antibiotic-free volumes are too small to impact the Mediterranean-wide regional scoring for this criterion.

The score for Criterion 4: Chemical Use is 0 out of 10, driven by the use of antibiotics classified by the World Health Organization as “Highly Important” and “Critically Important” to human health.

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: aquaculture operations source only sustainable feed ingredients, convert them efficiently and responsibly, and minimize and utilize the non-edible portion of farmed fish.*

Criterion 5 Summary

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	2.00	5.00	
F5.1b Source fishery sustainability score		-2.00	
F5.1: Wild Fish Use		4.60	
F5.2a Protein IN	54.94		
F5.2b Protein OUT	18.00		
F5.2: Net Protein Gain or Loss (%)	-67.24	3	
F5.3: Feed Footprint (hectares)	16.70	4	
C5 Feed Final Score		**4.05**	**YELLOW**
Critical?	NO		

Brief Summary

Calculations below show fishmeal and fish oil inclusion rates of 21% and 10%, respectively, and an FCR of 2.0. The majority of marine feed ingredients are sourced either from sustainable fisheries or processing byproducts. However, based on protein inputs and outputs, a 67.2% net loss of protein is experienced during production. A total of 17.16 hectares (ha) of ocean area and 0.56 ha of land area were calculated to be required to produce the marine and terrestrial feed ingredients necessary to produce 1 ton of farmed fish. The numerical score for Criterion 5: Feed is 4.05 out of 10.

Justification of Ranking

Factor 5.1. Wild Fish Use

To estimate wild fish use, Seafood Watch calculates the ratio of wild fish inputs (FI) to farmed fish outputs (FO). The FI:FO represents the fish conversion efficiency for the farmed species. Several metrics are utilized in this calculation:

1) Inclusion Rate: the percentage of fishmeal and fish oil included in formulated feeds (calculated separately for fishmeal and fish oil)
2) Yield Rate: the amount of fishmeal or oil extracted from whole wild fish
3) Economic Feed Conversion Ratio (eFCR): the ratio of feed inputs to farmed fish outputs, most simply calculated as the weight of feed used, divided by the weight of fish harvested.[2]

5.1a. Fish In to Fish Out (FI:FO) Ratio

Global averages for sea bass/seabream-specific inclusion rates and FCR were available in several FAO papers as follows:

Table 4. Fishmeal and fish oil inclusion levels as cited in primary literature

Source	Fish Meal and Fish Oil Inclusion Rates		Efficiency Rate
	Meal (%)	Oil (%)	FCR
Tacon and Metian (2008)	22–40	8–13	1.7–2.2
Tacon et al. (2011)	20–40	7–15	n/a

Since aquaculture feed development often occurs more quickly than the scientific literature can report, direct communications with academics, feed manufacturers, and fish farm managers is one of the most effective methods for gathering feed information that accurately reflects the realities of production. For example, recent advances in feed development have successfully decreased the amount of aquatic ingredients (fishmeal and fish oil) in sea bass/seabream feeds. Over the last 5 years, fishmeal inclusion levels have dropped to 20%–22% as opposed to upward of 40%, as cited in the literature sources above (pers. comm., Karapanagiotidis, 2013) (pers. comm., Papaharisis, 2013). Therefore, the fishmeal inclusion values used in the following calculations are based principally on personal communications with academic and industry experts, including representatives from the University of Thessaly and Aquark. These data were independently corroborated by a sea bass/seabream producer (Nireus Aquaculture S.A.) as well as a feed manufacturer (Biomar Hellenic S.A.).[3] Current inclusion levels are as follows:

Table 5. Current fishmeal and fish oil inclusion levels as provided by academics and industry experts

Source	Fish Meal and Fish Oil Inclusion Rates		Efficiency Rate
	Meal (%)	Oil (%)	FCR
Values Used for Calculations	21	10	2.0

[2] Seafood Watch considers economic FCRs, which includes mortalities and escapes.
[3] These experts provided valuable input via personal communications throughout Criterion 5: Feed.

The 10% fish oil inclusion rate is based on personal communications with experts. Note that this 10% inclusion is in the middle of the range cited in the literature in Table 4 (Tacon and Metian 2008) (Tacon et al. 2011).

Specific data on fishmeal and fish oil yields from whole forage fish were unavailable at the time of this report. Therefore, global average values of 22.5% yield for fishmeal and 5% yield for fish oil were taken from (Tacon and Metian 2008).

The following metrics and equations are used to calculate FI:FO.[4]

a) Fishmeal inclusion level = 21%
   Percentage of fishmeal from byproducts[5] = 36.5%
   → Fishmeal % = 21% – (21% × 36.5% ÷ 100) = 13.3%
b) Fish oil inclusion level = 10%
   Percentage of fish oil from byproducts[4] = 50% (based on input from the aforementioned sources)
   → Fish Oil % = 10% – (10% × 50% ÷ 100) = 5.0%

c) Fishmeal yield % = 22.5% (global average value taken from (Tacon and Metian 2008))
d) Fish oil yield % = 5.0% (global average value taken from (Tacon and Metian 2008))
e) Economic FCR = 2.0

$$FI:FO_{FishMEAL} = \left(\frac{a \times e}{c}\right) = \left(\frac{13.3 \times 2.0}{22.5}\right) = 1.18$$

$$FI:FO_{FishOIL} = \left(\frac{b \times e}{d}\right) = \left(\frac{5.0 \times 2.0}{5.0}\right) = 2.0$$

Final FI:FO value = the greater value of $FI:FO_{FishMEAL}$ or $FI:FO_{FishOIL}$
Final FI:FO value = 2.0

FI:FO score = 10 – (2.5 × FI:FO) = 10 – (2.5 × 2.0) = *5.0*

As shown above, fish oil has a larger FI:FO value than fishmeal, so fish oil drives the final FI:FO score of 5 out of 10.

Factor 5.1b. Source Fishery Sustainability

For European sea bass and gilthead seabream, marine feed ingredients originate mainly from the Pacific South American coast, with smaller contributions originating from the North East Atlantic and the North Sea; the main species of fish used in sea bass/seabream feeds are

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[4] This FI:FO equation in the Seafood Watch criteria is the same as that used by (Tacon and Metian 2008).
[5] Value based on expert input gathered via personal communications.

anchoveta, sardine, blue whiting, capelin, herring, Norway pout, sand eel, and sprat (IUCN 2007) (pers. comm., Papaharisis, 2013).

FishSource[6] is a database maintained by the Sustainable Fisheries Partnership; this database provides information and resources on the sustainability of global fish stocks. The following table summarizes the status of the wild stocks utilized for sea bass/seabream feeds.

Table 6. FishSource information on source fisheries for feed ingredients utilized in sea bass/seabream feeds

Species	Use	Status	FishSource Scores
SOUTH AMERICA			
Anchoveta *Engraulis ringens*	Very small amount used for human consumption; majority used for fishmeal	Fully exploited; precautionary management plans and strong fisher compliance with scientific advice	>6 - 10
Sardine *Stangomera bentincki*	Used for human consumption and fishmeal	Fully exploited; continuous scientific updates to the management plan to avoid overexploitation	>6 - 10
EUROPE			
Blue whiting *Micromesistius poutassou*	Mainly used for fishmeal; limited use for human consumption	Precautionary management and high compliance by fishers	>8 - 10
Capelin *Mallotus villosus*	Used for both fishmeal and human consumption – est. 60%:40%	Precautionary management based on scientific recommendations and high compliance by fishers	>6 - 10
Herring *Clupea harengus*	Primarily used for human consumption, but non-food grade fish and trimmings* may be used for fishmeal	Updated management plan (2008) is precautionary and based on robust science; high compliance by fishers; sustainable harvest	8 - 10
Norway pout *Trisopterus esmarkii*	Not used for human consumption	Precautionary management based on scientific recommendations and high compliance by fishers	>6 - 10
Sand eel *Ammodytidae*	Not used for human consumption	Currently no management plan yet stock assessments show robust populations	>6 - 10
Sprat *Sprattus sprattus*	Potential uses for human consumption but mainly used for fishmeal	State unknown, but evidence suggests management plan could be more precautionary	>6 - 10

* "Trimmings" refers to the non-edible byproducts from fish processed for human consumption (e.g., offal, heads, skin, fins, frames)

As shown, all the wild stocks utilized for sea bass/seabream feeds have FishSource scores above 6, with several species obtaining scores of 8 or higher (SFP 2014). These high scores indicate that these source fisheries are demonstrably sustainable and that there may be only minor concerns with respect to the sustainability and environmental impacts as a result of fishing. A penalty score of –2 out of –10 is assigned to this factor.

[6] www.fishsource.org

Factor 5.1. Wild Fish Use Score

Wild fish use score = FI:FO score + (FI:FO value × Sustainability score) ÷ 10
Wild fish use score = 5.0 + (2.00 × (–2)) ÷ 10 = 5.0 + (–0.40) = 4.60

The sustainability penalty is applied to reduce the FI:FO score, and generates a final numerical score for Factor 5.1: Wild Fish Use of 4.60 out of 10.

Factor 5.2. Net Protein Gain or Loss

Similar to fishmeal and fish oil inclusion levels in Factor 5.1 above, the protein content of sea bass/seabream feed as cited in the primary literature (43%–50% as reported in (Rana et al. 2009)) is shown to be outdated and no longer representative of current industry practices. Based on input from the aforementioned academics and corroborated by representatives from industry and a feed manufacturer, a protein content of 42% is used for these calculations.

Non-edible sources of feed protein include byproducts and processing trimmings, while edible crop sources of feed protein include oilseed cakes (e.g., rapeseed meal, sunflower meal, soya cake, soy protein concentrate) and gluten products (corn and wheat) (personal communications[6]).

Table 7. Values utilized in net protein gain/loss calculations

	Parameter	Value	Source
Protein Inputs	Protein content of feed	42%	Personal communications[7]
	eFCR	2.0	Table C above
	Percentage of feed protein from non-edible sources (by-products, etc.)	16%	Personal communications[6]
	Percentage of feed protein from edible crop sources	65%	Personal communications[6]
Protein Outputs	Protein content of whole harvested fish	18%	Boyd 2007
	Edible yield of harvested farmed fish	100%	Fish are sold whole
	Percentage of by-products from harvested fish used for other food production	0%	Fish are sold whole

Protein IN = [42 – (42 × (16 + (0.286 × 65)) / 100)] × 2.0 = 54.94
Protein OUT = (18/100) × [(100 + (0 × (100-100)) / 100)] = 18

Net protein loss = (Protein OUT – Protein IN) / Protein IN = **–67.2%**

[7] Value based on expert input gathered via personal communications.

67.2% of the protein feed inputs for sea bass/seabream are lost during production, indicating that the protein conversion efficiency of this practice is relatively poor and an area of concern from a resource-utilization standpoint. This net loss could be reduced through continued increased of byproduct use for feed protein.

Factor 5.2 receives a score of 3 out of 10 in the Seafood Watch criteria.

Factor 5.3. Feed Footprint

Sea bass/seabream feeds contain a total of 31% aquatic feed ingredients (fishmeal and fish oil; see Table 5 above), 3.36% terrestrial animal ingredients (e.g., bloodmeal, feathermeal, and hemoglobin products) (personal communications[6]) and 65.64% terrestrial crop ingredients (personal communications[6]).

A total of 16.12 hectares (ha) of ocean area were calculated to be required to produce the feed ingredients for 1 ton of farmed sea bass/seabream. An additional 0.57 ha of land area were calculated to be required to produce the terrestrial feed ingredients associated with 1 ton of farmed fish (see the Seafood Watch criteria for calculation details). This totals 16.70 ha of ocean and land area required, leading to a numerical score for Factor 5.3 of 4 out of 10.

Criterion 5 – Feed

When the scores for Factors 5.1, 5.2, and 5.3 are combined, the final numerical score for Criterion 5: Feed is 4.05 out of 10.

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: aquaculture operations pose no substantial risk of deleterious effects to wild populations associated with the escape of farmed fish or other unintentionally introduced species.*

Criterion 6 Summary

Escape parameters	Value	Score	
F6.1 Escape Risk		2.00	
F6.1a Recapture and mortality (%)	25		
F6.1b Invasiveness		5	
C6 Escape Final Score		**4.00**	**YELLOW**
Critical?	NO		

Brief Summary

The open nature of net pens indicates that there is a high inherent risk of escape associated with these production systems. Both sea bass and seabream are native to the Mediterranean. Though the vast majority of fish are sourced from domesticated, hatchery-reared broodstock and therefore have some genetic differentiation from wild populations, there is no indication that escapes have had negative genetic effects on wild populations. The numerical score for Criterion 6: Escapes is 4.00 out of 10, based principally on precaution surrounding the high escape risk from marine net pens.

Justification of Ranking

The escape criterion combines the risk of escape with the potential for ecological impact of the escapees.

Factor 6.1a. Escape risk

Although it is known that sea bass and seabream escape from Mediterranean farms, the extent and number are not well known (Toledo Guedes et al. 2009). Nets are checked by divers and regularly repaired or replaced, but without specific data on escape numbers, open net pens with best management practices in place to prevent escapes are considered a high risk according to the Seafood Watch criteria, with an associated Escape Risk score of 2 out of 10.

This Escape Risk score can be improved if it can be demonstrated that recapture or direct mortalities at the farm site reduce the potential impacts of the escapees. Robust data are sparse on the fate and effects of escapes from sea bass and seabream farms in the

Mediterranean. Two studies (Dempster et al. 2002) (Arechavala-Lopez et al. 2011) demonstrated that escaped sea bass show high fidelity to farm areas, meaning that they tend to stay close to the farm site and are more easily recaptured than species that show high and rapid dispersal rates (e.g., Atlantic cod, *Gadus morhua*; Atlantic salmon, *Salmo salar*) (Uglem et al. 2008, 2010) (Skilbrei et al. 2010). Additionally, (Arechavala-Lopez et al. 2011) suggests that the post-escape mortality of sea bass and seabream is likely to be high due to fishing and natural predation, thus minimizing the potential impacts of escaped fish on the surrounding ecosystem; the Mediterranean region is known for active recreational fishing around farm areas where an escape is known to have occurred (Arechavala-Lopez et al. 2011). Although it is considered likely that there are significant recaptures and mortalities of escapes, particularly from fishing activities, there is insufficient data with which to set a specific recapture or mortality score. Actual recapture rates may be higher ((Arechavala-Lopez et al. 2012) suggests up to 60%), but this assessment has adopted a moderate score of 25% on a precautionary basis to represent the proportion of escapees either recaptured or eliminated by predation.

The recapture rate of 25% improves the Factor 6.1a: Escape Risk score from 2 out of 10 to 4 out of 10.

Factor 6.1b. Invasiveness

Escaped fish can compete with wild fish stocks for resources such as food, space, shelter, and mates, and the degree of competition increases as more escapees enter the surrounding environment. Escaped piscivores (carnivorous fish) such as sea bass/seabream can also alter trophic interactions by increasing predatory pressures on natural prey populations (Guedes et al. 2009).

D. labrax and *S. aurata* are both native to the Mediterranean Sea, so the risks associated with escapes of non-natives are not applicable to this assessment. However, selective breeding has altered the genetic composition of cultured populations, creating the potential for escapees to influence wild stocks at a genetic level. In addition, the escape of a large number of predatory fish can have an impact on local prey species (Guedes et al. 2009).

Domestication of the European sea bass was initiated in the mid-1980s and most stocks are now derived from broodstock on which selective breeding has occurred for several generations (Haffray et al. 2007). The high fecundity of the species allows high selection intensity and facilitates rapid genetic gain; major traits selected for are growth, morphology, and/or carcass yield (Haffray et al. 2007). A review of European sea bass genomics by Volkaert et al. (2008) reports reduced genetic diversity among hatchery-raised fish; however, some farmed stocks include small numbers of wild-caught broodstock to avoid inbreeding. This is sufficient to keep major genetic lines outbred. Also, multiple studies have concluded that, although more research is necessary, there appears to be only limited genetic differentiation between wild populations and farmed stocks (Haffray et al. 2007, Volkaert et al. 2008).

The same appears to be true for seabream. Despite a large-scale selective breeding program for seabream initiated in 2002, genetic analysis of 13 Italian broodstocks revealed that the number of microsatellite alleles was not significantly different from those of natural populations (Sola et al. 2007). Additionally, no decline of genetic variability parameters in wild populations has been observed (Sola et al. 2007).

Though there is clear evidence that selective breeding for multiple generations has altered the genetic and phenotypic variance of cultured sea bass and seabream populations, there is no indication that escapes have caused a loss of genetic fitness in wild populations. However, escapes are known to impact surrounding ecosystems through competition with wild populations and increased predation on prey organisms (Guedes et al. 2009). For these reasons, this factor receives a score of 4 out of 10.

When the Factor 6.1a and 6.1b scores are combined, the final numerical score for Criterion 6: Escapes is 4.00 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: aquaculture operations pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites.*

Criterion 7 Summary

Pathogen and parasite parameters	Score	
C7 Biosecurity	4.00	
C7 Disease; pathogen and parasite Final Score	**4.00**	**YELLOW**
Critical?	**NO**	

Brief Summary

Several diseases associated with sea bass/seabream farms have been shown to have environmental and economic impacts, but there is no evidence of transmission of diseases from farmed fish to wild populations. Though the open nature of net pens represents inherently low biosecurity of the system and allows for any disease agents to transfer freely into and out of the farm site, the increased use of vaccines has greatly reduced the frequency and magnitude of disease outbreaks in recent years. The score for Criterion 7: Disease is 4.00 out of 10, driven principally by precaution warranted by marine open net pens.

Justification of Ranking

Several native pathogens affect European sea bass and gilthead seabream, including viruses, bacteria, fungi, and parasites. Though vaccines have played a vital role in combating disease and reducing the amount of chemicals needed in recent years (Plumb and Hanson 2011) (pers. comm., Papaharisis, 2013), the most severe production losses have arisen from viral encephalopathy and retinopathy (VER), bacterial infections causing pasteurellosis, and vibriosis (FAO 2005) (Ozturk and Altinok 2014). Parasitic infection in farmed sea bass and seabream is also known to be problematic (FAO 2005). Specific numbers of disease outbreaks and related mortalities were not available at the time of this assessment.

Viral encephalopathy and retinopathy, also known as viral nervous necrosis (VNN) or fish encephalitis, is a native disease causing neurological disorders. Its prevalence in wild fish from the Middle Adriatic Sea was reported as 4.4% (Guercio et al. 2004). VER is highly pathogenic in sea bass but appears less so in seabream. For example, even when exposed during culture, many seabream do not display symptoms of VER (Sweetman et al. 1996). However, further research found that, while infected bass and bream may be asymptomatic, they can still act as carriers with the ability to infect cohabitating fish (Castric et al. 2001).

Parasitic infection in farmed sea bass and seabream is a significant production concern. Internal microscopic (myxosporean) parasites have been reported in a high percentage of farmed sea bass and seabream (Fioravanti et al. 2006). External monogenean parasitic flatworms also impact sea bass/seabream operations: *Furnestinia echeneis* in seabream and *Diplectanum aequans* in sea bass have been found in the gills of cultured fish (Euzet and Audouin 1959). Most recently, *Gyrodactylus orecchiae* was the first gyrodactylid described on sea bass/seabream, causing up to 10% mortality (Paladini et al. 2009). Two recent studies have concluded that farmed sea bass and seabream have minimal interactions with farm-associated wild fish in terms of disease and parasitic transmission (Mladineo 2009) (Fernandez-Jover 2010).

Currently there is no empirical evidence showing transmission of pathogens from farmed sea bass and seabream to wild fish (Ozturk and Altinok 2014). However, aquatic transfer between pens at the same farming site has been shown (Castric et al. 2001), making it theoretically possible for infected farmed sea bass and seabream to transmit native pathogens to wild fish stocks, particularly in pen production systems that discharge untreated effluent into the natural environment.

In summary, although there is no evidence of native disease outbreaks in wild fish resulting from the transmissions of pathogens from sea bass and seabream net pens, a precautionary approach is appropriate because intensive farming in open production systems creates conditions that serve to amplify diseases and parasitic infections. Therefore, Criterion 7: Disease receives a moderate score of 4.00 out of 10.

Criterion 8: 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: aquaculture operations use eggs, larvae, or juvenile fish produced from farm-raised broodstocks, use minimal numbers, or source them from demonstrably sustainable fisheries.*

Criterion 8 Summary

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock, natural (passive) settlement, or sourced from sustainable fisheries	90	
C8 Source of stock Final Score	**9.00**	**GREEN**

Brief Summary

The majority of sea bass and seabream juveniles are produced from hatchery-reared broodstock. Although small numbers of wild-caught broodstock may be utilized, these numbers are not significant enough to have population-level effects on wild stocks (both *D. labrax* and *S. aurata* are species of Least Concern as classified by the International Union for Conservation of Nature (IUCN)) and only serve to add genetic diversity to selectively bred lines. Thus, the Mediterranean sea bass/seabream industry can be said to be >90% independent of wild stocks and Criterion 8: Source of Stock receives a numerical score of 9 out of 10.

Justification of Ranking

Historically, wild-caught fry have been used extensively; however, this practice limited production and caused rapid depletion of wild stocks. In the late 1970s and early 1980s, technological advances allowed for hatchery production of fry and larvae. Currently, on-land hatcheries utilize mainly domestic broodstock, with some programs including small numbers of wild individuals to maintain genetic variation and avoid inbreeding (Haffray et al. 2007). In addition to the independent hatcheries, many farms today have their own integrated hatchery operations.

Though some hatcheries do collect small numbers of broodstock from wild populations, the numbers taken are insignificant from a population-level perspective, and this practice has been shown to not have population-level effects on these wild stocks (Haffray et al. 2007). These wild-caught individuals add genetic diversity to selectively bred lines and keep the farmed fish genetically similar to wild fish (Sola et al. 2007). The majority of broodstock have been selectively bred for several generations, removing over 90% of the industry's dependence on wild genetic resources. For these reasons, Criterion 8: Source of Stock receives a final numerical score of 9.00 out of 10.

Criterion 9X: Wildlife and Predator Mortalities

A measure of the effects of deliberate or accidental mortality on the populations of affected species of predators or other wildlife.
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

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score	**-2.00**	**GREEN**
Critical?	NO	

Brief Summary
Though sea bass/seabream aquaculture operations attract a variety of predators and wildlife, mortalities are limited to exceptional cases and no incidents of mortalities of endangered species have occurred. Thus, Exceptional Criterion 9X scores –2 out of –10.

Justification of Ranking
Predators are attracted to fish farms by the presence of such large numbers of fish (Beveridge 2001). Birds represent the principal predatory challenge to sea bass/seabream farms in the Mediterranean, although pens attract a range of predatory species, including fish and mammals (Beveridge 2001).

One predator reported to attack sea bass/seabream pens is the Mediterranean monk seal, *Monachus monachus* (Guclusoy and Savas 2003). This marine mammal is listed as "Critically Endangered" on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2014) and is considered to be the rarest and most endangered of all pinnipeds (Anguilar and Lowry 2008). Sea bass/seabream farmers in areas of Turkey have reportedly encountered these predators on several occasions, but non-lethal deterrents (such as anti-predator nets) are employed and no evidence of mortalities appears in the literature or through personal communications (Guclusoy and Savas 2003).

Bottlenose dolphins (*Tursiops truncatus*) have been shown to prey on both farmed fish within pens as well as wild fish in the general farm area (Diaz Lopez 2006). Several studies have demonstrated that, while dolphins occasionally experience incidental capture and entanglement in anti-predator nets (e.g., (Wursig and Gailey 2002) (Diaz Lopez and Shirai 2007)), these events, in addition to those noted above, are rare and that effective management and prevention measures limit mortalities to exceptional cases. Bottlenose dolphins are classified as a species of "Least Concern" by the IUCN (IUCN, 2014).

Exceptional Criterion 9X scores –2 out of –10.

Criterion 10X: Escape of Unintentionally Introduced Species

A measure of the escape risk (introduction to the wild) of alien species other than the principle farmed species unintentionally transported during live animal shipments.

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	
C10Xa International or trans-waterbody live animal shipments (%)	10.00	
C10Xb Biosecurity of source/destination	10.00	
C10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**

Brief Summary
Despite live-animal transport across national borders (e.g., from a hatchery in Italy to a marine net-pen site in Greece), all sea bass/seabream farming takes place in the Mediterranean Sea, which is considered an ecologically homogenous water body for the purposes of this assessment. Therefore, no trans-water body shipments occur and no penalty is assigned for Exceptional Criterion 10X.

Justification of Ranking
Because no trans-water body movements exist in the sea bass/seabream farming industry, this Criterion is not necessary to be scored (i.e., there is no deduction in this exceptional criterion).

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Appendix 1 - Data points and all scoring calculations

This is a condensed version of the criteria and scoring sheet to provide access to all data points and calculations. See the Seafood Watch Aquaculture Criteria document for a full explanation of the criteria, calculations and scores. Yellow cells represent data entry points.

Criterion 1: Data quality and availability

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	7.5	7.5
Effluent	Yes	7.5	7.5
Locations/habitats	Yes	7.5	7.5
Predators and wildlife	Yes	2.5	2.5
Chemical use	Yes	2.5	2.5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	7.5	7.5
Source of stock	Yes	10	10
Other – (e.g. GHG emissions)	No	Not relevant	n/a
Total			**55**

C1 Data Final Score	**6.11**	**YELLOW**

Criterion 2: Effluents

Effluent Evidence-Based Assessment

C2 Effluent Final Score	**6.00**	**YELLOW**

Criterion 3: Habitat

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		4.00	
F3.2a Content of habitat regulations	4.00		
F3.2b Enforcement of habitat regulations	4.75		
F3.2 Regulatory or management effectiveness score		7.60	
C3 Habitat Final Score		**5.20**	**YELLOW**
Critical?	NO		

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	**0.00**	
C4 Chemical Use Final Score	**0.00**	**RED**
Critical?	NO	

Criterion 5: Feed

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	2.00	5.00	
F5.1b Source fishery sustainability score		-2.00	
F5.1: Wild Fish Use		4.60	
F5.2a Protein IN	54.94		
F5.2b Protein OUT	18.00		
F5.2: Net Protein Gain or Loss (%)	-67.24	3	
F5.3: Feed Footprint (hectares)	16.70	4	
C5 Feed Final Score		**4.05**	**YELLOW**
Critical?	NO		

Criterion 6: Escapes

Escape parameters	Value	Score	
F6.1 Escape Risk		2.00	
F6.1a Recapture and mortality (%)	25		
F6.1b Invasiveness		4	
C6 Escape Final Score		**4.00**	**YELLOW**
Critical?	NO		

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	4.00	
C7 Disease; pathogen and parasite Final Score	**4.00**	**YELLOW**
Critical?	**NO**	

Criterion 8: Source of Stock

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock, natural (passive) settlement, or sourced from sustainable fisheries	90	
C8 Source of stock Final Score	**9.00**	**GREEN**

Exceptional Criterion 9X: Wildlife mortalities

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score	**-2.00**	**GREEN**
Critical?	NO	

Exceptional Criterion 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
C10Xa International or trans-waterbody live animal shipments (%)	10.00	
C10Xb Biosecurity of source/destination	10.00	
C10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**