Seafood Watch® Standard for Salmon Fisheries

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Seafood Watch Ratings

The Seafood Watch Criteria for Salmon Fisheries are used to produce assessments for wild-capture fisheries on salmon resulting in a Seafood Watch rating of Best Choice (green), Good Alternative (yellow), or Avoid (red). The assessment criteria are used to determine a final numerical score as well as numerical and categorical sub-scores for each criterion. These scores are translated to a final Seafood Watch color rating according to the methodology described in the table below. The table also describes how Seafood Watch defines each of these categories. The narrative descriptions of each Seafood Watch color rating category, and the guiding principles listed below, compose the framework the criteria are based on, and should be considered when providing feedback on any aspect of the criteria.

Best Choice	Final Score >3.2, and either Criterion 1 or Criterion 3 (or both) is Green, and no Red Criteria, and no Critical scores	Wild-caught and farm-raised seafood on the "Best Choice" list is ecologically sustainable, well managed and caught or farmed in ways that cause little or no harm to habitats or other wildlife. These operations align with all of our guiding principles.
Good Alternative	Final score >2.2, and no more than one Red Criterion, and no Critical scores, and does not meet the criteria for Best Choice (above)	Wild-caught and farm-raised seafood on the "Good Alternative" list cannot be considered fully sustainable at this time. They align with most of our guiding principles, but there is either one conservation concern needing substantial improvement, or there is significant uncertainty associated with the impacts of this fishery or aquaculture operations.
Avoid	Final Score <=2.2, or two or more Red Criteria, or one or more Critical scores.	Wild-caught and farm-raised seafood on the "Avoid" list are caught or farmed in ways that have a high risk of causing significant harm to the environment. They do not align with our guiding principles and are considered unsustainable due to either a critical conservation concern, or multiple areas where improvement is needed.

Seafood Watch Guiding Principles

Seafood Watch® defines "sustainable seafood" as seafood from sources, whether fished or farmed, that can maintain or increase production without jeopardizing the structure and function of affected ecosystems. Sustainable wild capture fisheries:

1. **Follow the principles of ecosystem-based fisheries management**
   The fishery is managed to ensure the integrity of the entire ecosystem, rather than solely focusing on maintenance of single species stock productivity. To the extent allowed by the current state of the science, ecological interactions affected by the fishery are understood and protected, and the structure and function of the ecosystem is maintained.

2. **Ensure all affected stocks[1] are healthy and abundant**
   Abundance, size, sex, age and genetic structure of the main species affected by the fishery (not limited to target species) is maintained at levels that do not impair recruitment or long-term productivity of the stocks or fulfillment of their role in the ecosystem and food web.

   Abundance of the main species affected by the fishery should be at, above, or fluctuating around levels that allow for the long-term production of maximum sustainable yield.

3. **Fish all affected stocks at sustainable levels**
   Fishing mortality for the main species affected by the fishery should be appropriate given current abundance and inherent resilience to fishing while accounting for scientific uncertainty, management uncertainty, and non-fishery impacts such as habitat degradation.

   The cumulative fishing mortality experienced by affected species must be at or below the level that produces maximum sustainable yield for single-species fisheries on typical species that are at target levels. Fishing mortality may need to be lower than the level that produces maximum sustainable yield in certain cases such as multispecies fisheries, highly vulnerable species, or fisheries with high uncertainty.

   For species that are depleted below target levels, fishing mortality must be at or below a level that allows the species to recover to its target abundance.

4. **Minimize bycatch**
   Seafood Watch defines bycatch as all fisheries-related mortality or injury other than the retained catch. Examples include discards, endangered or threatened species catch, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is valid scientific evidence of high post-release survival and there is no documented evidence of negative impacts at the population level.

   The fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss and by efficiently using marine resources as bait.

5. **Have no more than a negligible impact on any threatened, endangered or protected species**
   The fishery avoids catch of any threatened, endangered or protected (ETP) species. If any ETP species are inadvertently caught, the fishery ensures and can demonstrate that it has no more than a negligible impact on these populations.

6. **The fishery is managed to sustain the long-term productivity of all affected species.**
   Management should be appropriate for the inherent resilience of affected marine life and should incorporate data sufficient to assess the affected species and manage fishing mortality to ensure little risk of depletion. Measures should be implemented and enforced to ensure that fishery mortality does not threaten the long-term productivity or ecological role of any species in the future.

[1] "Affected" stocks include all stocks affected by the fishery, no matter whether target or bycatch, or whether they are ultimately retained or discarded.

The management strategy has a high chance of preventing declines in stock productivity by taking into account the level of uncertainty, other impacts on the stock, and the potential for increased pressure in the future.

The management strategy effectively prevents negative population impacts on bycatch species, particularly species of concern.

7. **Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs.**
The fishery does not adversely affect the physical structure of the seafloor or associated biological communities.

If high-impact gears (e.g. trawls, dredges) are used, vulnerable seafloor habitats (e.g. corals, seamounts) are not fished, and potential damage to the seafloor is mitigated through substantial spatial protection, gear modifications and/or other highly effective methods.

8. **Maintain the trophic role of all marine life**
All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web, as informed by the best available science.

9. **Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts**
Fishing activities must not result in harmful changes such as depletion of dependent predators, trophic cascades, or phase shifts.

This may require fishing certain species (e.g. forage species) well below maximum sustainable yield and maintaining populations of these species well above the biomass that produces maximum sustainable yield.

10. **Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance or genetic integrity of wild stocks**
Any enhancement activities are conducted at levels that do not negatively affect wild stocks by reducing diversity, abundance or genetic integrity.

Management of fisheries targeting enhanced stocks ensure that there are no negative impacts on the wild stocks, in line with the guiding principles described above, as a result of the fisheries. Enhancement activities do not negatively affect the ecosystem through density dependent competition or any other means, as informed by the best available science.

Seafood Watch Criteria for Salmon Fisheries

The Monterey Bay Aquarium is committed to inspiring conservation of the oceans. To this end, Seafood Watch®, a program of the Monterey Bay Aquarium, researches and evaluates the sustainability of fisheries products and shares these seafood recommendations with the public and other interested parties in several forms, including regionally specific Seafood Watch pocket guides, smartphone apps and online at www.seafoodwatch.org.

The criteria laid out in this document allow assessment of the relative sustainability of salmon fisheries according to the guiding principles and conservation ethic of the Monterey Bay Aquarium. Farmed seafood sources are evaluated with a different set of criteria.

Seafood Watch® defines "sustainable seafood" as seafood from sources, whether fished or farmed, that can maintain or increase production without jeopardizing the structure and function of affected ecosystems. Sustainable wild-capture fisheries should ensure that the abundance of both targeted and incidentally caught species is maintained in the long term at levels that allow the species to fulfill its ecological role* while the structure, productivity, function and diversity of the habitat and ecosystem are all maintained. A management system should be in place that enforces all local, national and international laws to ensure long-term productivity of the resource and integrity of the ecosystem by adhering to the precautionary approach and responding to changing circumstances.

Scope
Seafood Watch® recommendations apply to a single stock or species caught in a single fishery as defined by gear type, region and management body.

Salmon Fisheries

Salmon are a unique group of fish with life-history characteristics and behaviors that present unique challenges to management of fisheries for salmon species. As such, salmon fisheries are significantly different to typical wild-capture fisheries and have some unique characteristics. In order to ensure that Seafood Watch assessments consider these unique characteristics and the conservation concerns associated with these fisheries we have developed a modified set of criteria for assessing salmon fisheries. One of the major considerations within this set of criteria is the impacts of artificial production which is widely used throughout salmon fisheries across the globe.

The Seafood Watch Criteria for Salmon Fisheries and contains many elements common to the Seafood Watch Criteria for Fisheries. Text unique to the Criteria for Salmon Fisheries is indicated in blue.

Several key terms relevant to salmon fisheries may be unfamiliar to some readers. In addition to the glossary and further explanation in the Appendices, the terms are outlined below.

Term	**Definition**	**Source**
Population	Within this standard, population refers to a group of naturally interbreeding salmon independent from other such groups. Indicators of a distinct salmon population may include: genetics, demographics, geographic isolation, and adaption to the local habitat. Populations may be defined by NOAA fisheries to aid in the implementation of the U.S. Endangered Species Act (ESA) and within salmon recovery plans. NOAA Fisheries considers hatchery-origin salmon to be part of a population in some cases (through interbreeding) but does not consider a population dependent on naturally spawning hatchery fish to be viable.	McElhany et al. 2000
Distinct Population Segment	Under the ESA, a distinct population segment—or DPS—is a vertebrate population or group of populations that is discrete from other populations of the same species and significant in relation to the entire species. NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS) released a joint policy defining the criteria for identifying a DPS. The ESA provides for listing species, subspecies, or distinct population segments of vertebrate species. ESA listings of salmon, including Atlantic salmon, are made by DPS.	USFWS and NOAA Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act (1996)
Evolutionary Significant Unit	A Pacific salmon population or group of populations. A salmon stock will be considered a DPS, and hence a "species" under the ESA, if it represents an evolutionary significant unit (ESU) of the biological species. According to USFWS and NOAA (1996), the stock must satisfy two criteria to be considered an ESU: (1) It must be substantially reproductively isolated from other nonspecific population units; and (2) it must represent an important component in the evolutionary legacy of the species.	USFWS and NOAA Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act (1996)
Conservation Unit	Defined by the Canadian Wild Salmon Policy (WSP) as "a group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonize naturally within an acceptable timeframe". Conservation Units (CUs) serve as fundamental units of biodiversity as well as accounting units for documenting progress in achieving the policy goals of the WSP	Department of Fisheries and Ocean Canada (DFO 2009a)
Designatable Unit	Designatable units (DUs) are used in Canada to identify groups of salmon (or other species) for consideration under the Species at Risk Act. DUs should be discrete and evolutionarily significant units of the taxonomic	COSEWIC Guidelines for Recognizing Designatable Units

	species, where "significant" means that the unit is important to the evolutionary legacy of the species as a whole and if lost would likely not be replaced through natural dispersion. Criteria used to identify DUs in Canada are similar to those used to identify DPSs in the USA (Mooers et al 2010).	
Stock Management Unit	One or more ESUs, CUs or populations of salmon, defined for purposes of SFW assessments. Generally, management goals (e.g., escapement goals) have been established at this aggregate level, but this may not always be the case. Stock management units (SMUs) may include hatchery-origin salmon, but in these cases separate escapement limits should be established for hatchery- and natural-origin salmon.	SFW definition (similar to definition within MSC 2018)
Maximum Fishing Mortality Threshold	The level of fishing mortality (F), on an annual basis, above which overfishing is occurring.	Pacific Coast Salmon Fishery Management Plan (PFMC 2016)
Minimum Stock Size Threshold	Overfished status occurs when the most recent 3-year geometric mean spawning escapement is less than the MSST.	Pacific Coast Salmon Fishery Management Plan (PFMC 2016)
Hatchery-origin	Salmon raised for a portion of their life within a hatchery facility before release into the natural environment. Synonymous with 'artificially produced' for the purposes of this standard.	
Natural-origin	Salmon living their entire lives in the natural environment. Synonymous with 'wild' for the purposes of this standard.	

Criterion 1 – Impacts of the Fishery on the Stock for which you want a Recommendation

Guiding principles

The wild stock is healthy and abundant.* Abundance, size, sex, age and genetic structure should be maintained at levels that do not impair the long-term productivity of the stock or fulfillment of its role in the ecosystem and food web.

Fish all affected stocks at sustainable levels. Fishing mortality should be appropriate given current abundance and inherent vulnerability to fishing while accounting for scientific uncertainty, management uncertainty, and non-fishery impacts such as habitat degradation.

The cumulative fishing mortality experienced by affected species must be at or below the level that produces maximum sustainable yield for single-species fisheries on typical species that are at target levels.

Fishing mortality may need to be lower than the level that produces maximum sustainable yield in certain cases such as multispecies fisheries, highly vulnerable species, or fisheries with high uncertainty.

For species that are depleted below target levels, fishing mortality must be at or below a level that allows the species to recover to its target abundance.

Assessment instructions

Evaluate Factors 1.1–1.2 under **Criterion 1** to score the major Stock Management Units (SMUs) of salmon caught in the fishery for which you want a recommendation. Evaluate Factors 2.1–2.3 under **Criterion 2** to score all main species in the fishery, including minor SMUs of the target species, bycatch and retained species, as well as any overfished, depleted, endangered, threatened or other species of concern that are regularly caught in the fishery.

Note that if wild stocks are assessed only in combination with hatchery-raised populations, the health of the wild stock cannot be considered better than “moderate concern.”

Factor 1.1 Abundance

Goal: *Stock abundance and size structure is maintained at a level that does not impair recruitment or productivity.*

The scoring of health of stock depends on the abundance of the wild stock and quality of data available. Advice for scoring data-poor fisheries or fisheries that do not use formal stock assessment techniques is incorporated into the table below. Further guidance is provided in Appendix 8. Examples and further explanation of underlined terms can be found in the Glossary.

Instructions: This factor is used to score the current abundance of the wild stocks caught within the fishery. In many cases there is a high level of variability in abundance between brood years. In order to account for this variability and improve the longevity of the report and recommendations, please ensure that the abundance is assessed against the relevant reference point for the most recent 15 year period (if the population is fluctuating around the **relevant reference point** please follow the **guidance here**). In cases where monitoring does not distinguish between artificially produced and wild fish, or where artificial production confounds interpretation of the status of the wild stock, factor 1.1 cannot receive a score higher than "moderate concern" as it will be considered unknown at best. *Note:* Official IUCN listings should be overridden by more recent and/or more specific classifications, where available (e.g., NMFS stock assessment showing stock is above target levels).

For further guidance on interpretation of the health of stocks or populations, see Appendix 1.

Score according to table below. In cases of unknown abundance, calculate the inherent vulnerability using the Productivity-Susceptibility Analysis (modified from MSC 2014) below this table.

Table 1.1.1S: Scoring guidelines for abundance of salmon stocks.

Conservation Concern	Description	Score
Very Low	1. All major SMUs encountered in the fishery are healthy and exceed appropriate reference points over 80% of the last 15 years; **AND** 2. None of the major SMUs encountered by the fishery are determined to be threatened or endangered by a national or international body, for example, IUCN, ESA, SARA, COSEWIC.	5
Low	1. The fishery does not meet the criteria for "very low concern" identified above; **AND** 2. More than 70% of major SMUs encountered in the fishery are: healthy and exceed appropriate reference points over 60% of the last 15 years; **OR**	3.67

	3. Where quantitative stock assessment is lacking, there is a data-limited assessment available and there is confidence that the stock is healthy and no conflicting indicators[2] (see Appendix 7) **AND** 4. None of the major SMUs encountered by the fishery are determined to be threatened or endangered by a national or international body, for example, IUCN, ESA, SARA, COSEWIC.	
Moderate	1. The fishery does not meet the criteria for "low concern" as identified above; **AND** 2. Abundance of majority of major SMUs (>50%) encountered in the fishery is unknown[3] relative to appropriate reference points and SMUs are **not** considered highly vulnerable; **OR** 3. The majority of major SMUs (>50%) encountered by the fishery exceed appropriate reference points over 50% of the last 15 years; **OR** 4. Where quantitative stock assessment is lacking, 50% of the major SMUs caught within the fishery demonstrate that: When: a. there are no stock data available, **OR** b. there are no appropriate reference points, **OR** c. a data-limited assessment available and there is enough uncertainty that there is little confidence in the result, **OR** d. data limited assessment methodologies provide conflicting conclusions,	2.33

[2] Guidance on "appropriate data-limited assessment methods" to be developed. Until that time, Appendix 7 is provided to illustrate examples only and these indicators and thresholds should not be assumed to be appropriate for all fisheries. Data and assessments to be provided by the fisheries and verified by expert input. See also "recent stock assessment" definition for guidance on consideration of the currency of data-limited assessments.

[3] Abundance is considered to be unknown where there is no distinction made between wild origin salmon and hatchery origin salmon when assessing stock health against management goals or reference points.

	SUCH THAT: **e.** the Data Limited Stock Assessment Decision Tree (see Appendix 7) requires that a Productivity Susceptibility Analysis be conducted, it is determined that the stock is NOT highly vulnerable; **OR** 5. Quantitative stock assessment is lacking, and 50% of the major SMUs caught within the fishery indicate that status is not of concern, *e.g.,* stock is classified by management body as not overfished or has IUCN "Least Concern" status; **AND** 6. None of the major SMUs encountered by the fishery are determined to be threatened or endangered by a national or international body, for example, IUCN, ESA, SARA, COSEWIC.	
High	1. The fishery does not meet the criteria for "moderate concern" as identified above; **AND** 2. The majority of major SMUs (>50%) encountered in the fishery are failing to meet appropriate reference points more than 50% of the last 15 years; **OR** 3. One or more of the major SMUs[4] encountered by the fishery is determined to be endangered or threatened by a national or international body, for example, IUCN, ESA, SARA, COSEWIC[5] **OR**	1

[4] Endangered or threatened status under the United States Endangered Species Act occurs at the Ecologically Significant Unit (ESU) level. For the purposes of a Seafood Watch assessment, a listed ESU should be treated as a SMU.

[5] Salmon determined to be endangered or threatened by COSEWIC should be considered endangered or threatened for the purposes of a Seafood Watch assessment, regardless of whether they are listed under the SARA.

	4. Available appropriate data-limited assessment method(s) (see Appendix 7) for >50% of major SMUs caught in the fishery suggest status of stock is poor; **OR** 5. When; a. there are no stock data available, **OR** b. there are no appropriate reference points, **OR** c. a data-limited assessment available and there is little confidence in the result due to high uncertainty, **OR** d. data limited assessment methodologies provide conflicting conclusions, **SUCH THAT:** e. the Data Limited Stock Assessment Decision Tree (see Appendix 7) requires that a Productivity Susceptibility Analysis be conducted, it is determined that the stock is highly vulnerable.	

Instructions for Productivity-Susceptibility Analysis (for determining vulnerability)

To determine whether a species is highly vulnerable (only if needed for rating the species using the table above): **If the species is a shark, sea turtle, seabird, marine mammal or coral, it is automatically considered to have "high" inherent vulnerability.** The default "high vulnerability" score for these taxa can be overridden in cases where there is evidence that the population's status is not of high concern. For teleost fish and invertebrate species, score inherent vulnerability according to the PSA method described below, adapted from the Marine Stewardship Council (MSC) 2014 (available at https://www.msc.org/documents/scheme-documents/fisheries-certification-scheme-documents/fisheries-certification-requirements-version-2.0) with revisions made in 2020. Productivity attributes used in this methodology differ for fish and invertebrate species. When data are insufficient to score any given productivity attribute, that attribute can be left blank. Susceptibility attributes are assigned default values in cases where data are insufficient for scoring (see tables below).

Adapted steps from MSC instructions on conducting a PSA (for reference see description starting on page 87 of the MSC Fisheries Certification Requirements v2.0) with revisions made in 2020

1. The analyst will use the 'Seafood Watch PSA scoring tool' to calculate productivity and susceptibility scores
2. For each data-deficient stock combination (gear type, location, body of water) that is assessed using PSA, a separate PSA score will be calculated with this tool. Both productivity and susceptibility will be scored on a three-level risk scale: low, medium and high. Where there is limited or conflicting information for a productivity or susceptibility attribute, use the more precautionary (higher value) score.

3. For Productivity: See the productivity table for guidance. Note that lower productivity corresponds to higher risk (and vice versa). Additional information below for certain attributes:
   - Score the von Bertalanffy Growth Coefficient (K), the average maximum size and average size at maturity for fish species and invertebrate species as appropriate to their growth type.
   - Score the average maximum age for invertebrates and for finfish score average maximum age only when average maximum length is unavailable.
   - Score density dependence for invertebrate species only.
   - Score habitat quality for diadromous species only
   - If data are unavailable for a particular attribute, leave it unscored.
4. For Susceptibility: See the susceptibility table for guidance. Note that lower susceptibility corresponds to lower risk (and vice versa). Additional information below for certain attributes:
   - When scoring "areal overlap," "vertical overlap," and "seasonal overlap," consider *all* fisheries impacting the species.
   - "Selectivity" and "post-capture mortality" should be scored with reference to the fishery under assessment only.
   - Default values are provided in the table. Default values should be used unless there is evidence to the contrary.
   - For "Post-capture mortality" (PCM) in the absence of observer data or other verified field observations made during commercial fishing operations that indicate the individuals are released alive and post-release survivorship is high, the default value should be high. The analyst may adjust the default value when 1) a high score is allocated for selectivity and 2) a large portion of animals are returned alive and survive the encounter.
5. To calculate the overall score:
   - Productivity score (P) = arithmetic mean of the productivity attribute scores (p1, p2, p3, p4, p5, p6, p7, p8, and p9 where p8 is only used for invertebrates)
   - Susceptibility score (S) = arithmetic mean of the susceptibility attribute scores (s1, s2, s3, s4, s5)
   - Vulnerability score (V) = the Euclidean distance of 1 and 2 using the following formula: $V = \sqrt{P^2 + S^2}$
6. Vulnerability Score range:
   - < 2.64 = Low vulnerability
   - ≥ 2.64 and ≤ 3.18 = Medium vulnerability
   - > 3.18 = High vulnerability
7. Seafood Watch uses the high vulnerability threshold in the scoring table for 1.1 (effectively grouping low and medium vulnerability stocks).
8. PSA results of low to moderate vulnerability may be overridden with a "high vulnerability" score in cases where either:
   - the species has one or more extremely vulnerable attributes under "productivity" (e.g., produces fewer than ten young per year or lives greater than 40 years), OR
   - available evidence suggests a high concern with the status of similar species and/or neighboring related stocks

Table 1.1.2a: Productivity attributes and rankings (adapted from Marine Stewardship Council 2014):

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)
Average age at maturity	< 5 years	5-15 years	>15 years
Average maximum age (Use for invertebrates. Do not use for finfish when maximum length is available)	<10 years	10-25 years	>25 years
Von Bertalanffy (Brody) Growth Coefficient (K) (to be used for species that exhibit first order growth)	>0.25 (Patrick et al. 2009)	0.15-0.25 (Patrick et al. 2009)	<0.15 (Patrick et al. 2009)
Fecundity	>20,000 eggs per year	100-20,000 eggs per year	<100 eggs per year
Average maximum size (not to be used when scoring invertebrate species)	< 100 cm	100-300 cm	>300 cm
Average size at maturity (not to be used when scoring invertebrate species)	<40 cm	40-200 cm	>200 cm
Reproductive strategy	Broadcast spawner	Demersal egg layer or brooder	Live bearer
Density dependence (to be used when scoring invertebrate species only)	Compensatory dynamics at low population size demonstrated or likely	No depensatory or compensatory dynamics demonstrated or likely	Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely
Quality of Habitat (for diadromous species only)	Habitat is robust, no known degradation from non-fishery impacts.	Habitat has been moderately altered by non-fishing impacts **Default score if unknown**	Habitat has been substantially compromised from non-fishery impacts and thus has reduced capacity to support the species, for example, from dams, pollution, or coastal development.

Table 1.1.2b: Susceptibility attributes and rankings (adapted from Marine Stewardship Council 2014).

Susceptibility Attribute	**Low S (score = 1)**	**Medium S (score = 2)**	**High S (score = 3)**
Areal overlap (Considers all fisheries)	Vast majority (>90%) of species concentration (main geographic range) is unfished (considering all fisheries) (must have evidence)	Most (70%-90%) of species concentration is unfished by any fishery (must have evidence)	>30% of the species concentration is fished, considering all fisheries. **Default score if unknown**
Vertical overlap (Considers all fisheries)	Low overlap between fishing depths and depth range of species, i.e. most of the species depth range (>=66%) is unfished (considering all fisheries) (Must have evidence; unlikely for any "main species")	Medium overlap between fishing depths of depth range of species, considering all fisheries, i.e. species has considerable portion **(>=33%)** of depth range that is unfished (must have evidence)	High degree of overlap between fishing depths and depth range of species **Default score for target species, as well as any air-breathing animal, or when unknown**
Seasonal Availability (Considers all fisheries; score using the most conservative option)	Fisheries overlap with species <3 months/year (Griffiths *et al* 2017) OR Seasonal migrations decrease overlap with the fishery (Patrick et al. 2009)	Fisheries overlap with species 3-6 months/year (Griffiths *et al* 2017) OR Seasonal migrations do not substantially affect overlap with the fishery (Patrick et al. 2009)	Fisheries overlap with species >6 months/year (Griffiths *et al* 2017) **Default score if unknown** OR Seasonal migrations increase overlap with the fishery (Patrick et al. 2009)
Selectivity of fishery (Specific to fishery under assessment)	Species is not targeted AND is not likely to be captured by gear (e.g., average body size at maturity is smaller than mesh size (net fisheries), or species is not attracted to the bait used (line fisheries), or is too large to enter trap (pot/trap fisheries), etc. (if known, **<33%** of individuals of this	Species is targeted, or is incidentally encountered AND is not likely to escape the gear, BUT conditions under 'high risk' do not apply **Default score when conditions under 'high risk' do not apply**	Species is targeted or is incidentally encountered AND Attributes of the fishery, in combination with the species' biology or behavior, e.g. migratory bottlenecks, spawning aggregation, site fidelity, unusual attraction to gear, sequential

	species encountering gear are captured) Must have evidence		hermaphrodite, semelparity, segregation by sex, etc. increase its susceptibility to the gear: e.g. net mesh size allows retention of individuals below size at maturation, or fishery targets spawning aggregations or BOFFFFs (Hixon et al 2014) If effective management measures are in place to mitigate the effect of the behavior or requirement, the behavior and/or requirement need not be considered. **Default score for salmon if unknown**
Post-capture mortality (Specific to fishery under assessment)	Evidence of majority of captured individuals (>**66%**) released and survive post-capture	Evidence of some (**33-66%**) individuals released and survive post-capture	Retained species, or majority dead when released, or unknown **Default score for retained species or unknown**

Factor 1.2 Fishing Mortality

Goal: *Fishing mortality is appropriate for current state of the stock.*

NOTE: Ratings are based on fishing mortality/exploitation rate, e.g., F/F_{MSY} or suitable proxy. When determining whether a fishery is a substantial contributor, and/or whether fishing mortality is at or below a sustainable level, err on the side of caution when there is uncertainty. For further guidance, see Appendix 1 (guidance on evaluating fishing mortality).

Table 1.2.1S: Scoring guidelines for fishing mortality in salmon fisheries.

Conservation Concern	Description	Score
Low Concern	The majority (>70%) of major SMUs caught in the fishery demonstrate: 1. Probable (>50% chance) that fishing mortality from all sources (including ghost fishing, if applicable) is at or below a sustainable level that will allow population to maintain current level or rebuild if depleted and to fulfill its role in the ecosystem, e.g. either F_{MSY} or for species with an exceptional role in the ecosystem, a reference point that is appropriate for the species; **OR** 2. Species is non-native; **OR** 3. For C2 species, fishery is not a substantial contributor to fishing mortality or its contribution to mortality is expected to be low enough to not adversely affect population; **AND** 4. None of the major SMUs caught in the fishery are subject to overfishing (F>F_{MSY}).	5
Moderate Concern	1. Requirements for "low concern" are not met; **AND** 2. Less than 25% of the major SMUs caught in the fishery are subject to overfishing (F>F_{MSY}); **OR** 3. Fishing mortality relative to reference points is unknown or mortality-based reference points are not established.	3

High Concern	Twenty-five percent or more of the major SMUs caught in the fishery demonstrate that: 1. 1. Probable (>50% chance) or suspected that fishing mortality from all sources (including commercial, recreational, subsistence, and ghost fishing, if applicable) is above a sustainable level that is appropriate for the species (*i.e.,* a level that will allow a population to maintain abundance at or rebuild to B_{MSY} or a suitable proxy) (*e.g.*, overfishing is occurring); **AND** 2. For species assessed under Criterion 2: individual fishery's contribution is unknown or fishery is a substantial contributor.	1

Criterion 1 Score and Rank

Score = geometric mean (Factors 1.1, 1.2).

Rank is based on the Score as follows:
- >3.2 = **Green**
- >2.2 and <=3.2 = **Yellow**
- <=2.2 = **Red**

Criterion 2 – Impacts on Other Capture Species

Guiding principles

The fishery minimizes bycatch. Seafood Watch® defines bycatch as all fisheries-related mortality or injury other than the retained catch. Examples include discards, endangered or threatened species catch, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is valid scientific evidence of high post-release survival **and** there is no documented evidence of negative impacts at the population level.

Fishing mortality does not threaten populations or impede the ecological role of any marine life. Fishing mortality should be appropriate given each impacted species' abundance and productivity, accounting for scientific uncertainty, management uncertainty and non-fishery impacts such as habitat degradation.

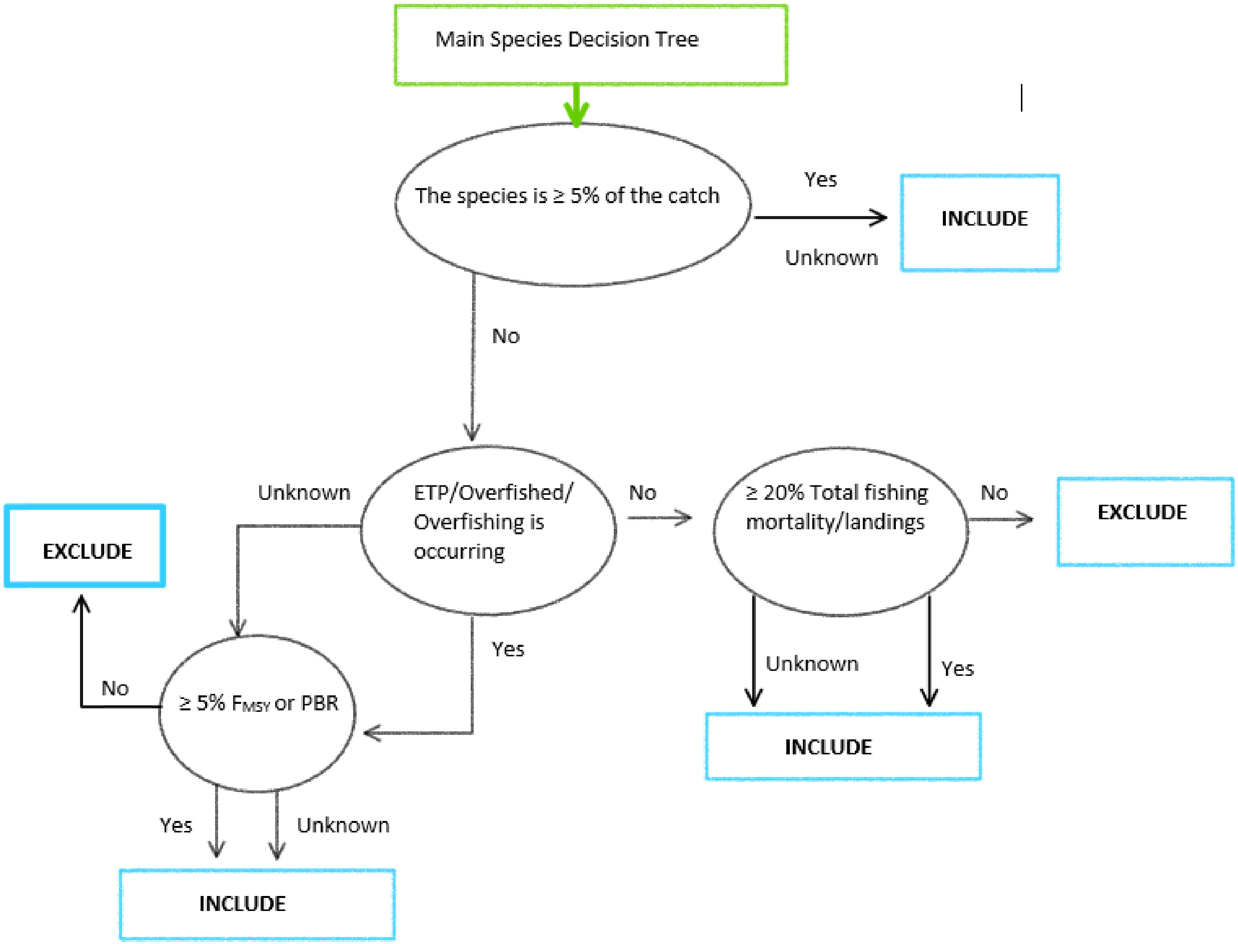
Assessment instructions

The Criterion 2 score for the stock for which you want a recommendation is the lowest score of all the other main species caught with it, multiplied by the discard rate. A species is included in the assessment as a **main species** if:

- A common component of the catch (as guidance, >5% of the catch in most cases),
- Species of concern, where catch occurs regularly and may significantly contribute to the conservation concern (i.e. more than a negligible and/or sporadic level of catch) (as guidance, mortality of the species caused by this fishery is >5% of a sustainable level), **or**
- Fishery is one of the main sources of mortality for the species, including bait species if known (as guidance, approx. 20% or more of total mortality).
- In fisheries which use bait, the bait species should be treated as a bycatch species if it meets the main species criteria outlined above. If the species used as bait are unknown but together account for greater than 5% of the catch and no other main species have been identified, then add 'unknown finfish' with abundance and fishing mortality both scored as "moderate concern."

Note: main species should include only those species that can be caught together in a set. It should not include species that are caught during separate hauls/harvest actions/attempts/sets, even though they may be targeted or caught opportunistically in the same area, using the same gear, and potentially on the same trip.

To help identify main species within the fishery being assessed, please consider the decision tree below:



In some cases, bycatch or retained species in the fishery are not known. If species are unknown, or if the species caught are known but are unassessed, Appendix 2 should be used to aid scoring. If some bycatch or retained species are known but information is incomplete (e.g., some or all retained species are recorded but bycatch species are not, or some bycatch species are assessed by the management body and some are not), assess each known species following guidance for "known species" **and** assess the fishery following guidance for "unknown species" under each Factor. Scoring for this criterion is based on the worst case, so the lowest of these scores will be used.

If there is no bycatch and no other species landed, the fishery receives a score of five for this criterion and the remaining questions in Criterion 2 can be skipped; the assessor can continue with Criterion 3.

Factor 2.1 Abundance

Goal: *Stock abundance and size structure of all main bycatch species/stocks is maintained at a level that does not impair recruitment or productivity.*

Known and assessed species

Salmon—for example, minor SMUs of the target species—should be assessed using the table presented in Factor 1.1 above. Non-salmon should be assessed using the scoring table below. In cases where there is no quantitative stock assessment available, use the data-limited stock assessment decision tree. Where directed by the data-limited stock assessment decision tree, calculate the inherent vulnerability using the Productivity-Susceptibility Analysis (MSC 2014) described below this table and in Table 1.1.2.

Table 2.1.1: Scoring guidelines for abundance of non-salmon.

Conservation Concern	Description	Score
Very Low	1. a. There is a recent stock assessment or update that has been approved through a robust scientific peer review process; **AND** b. Biomass is estimated to be above or fluctuating around a target reference point appropriate for the species (that is based on up to date life-history and spatial distribution information); **OR** 2. Stock is at or very near its historic high or virgin biomass; **OR** 3. Species is non-native.	5
Low	1. There is a quantitative stock assessment that is no more than 10 years old **AND** the biomass does not meet all the requirements for "very low concern," but: a. is above a limit reference point appropriate for the species , (that is based on up-to-date life-history and spatial distribution information) and at least 75% of the target reference point. (*i.e.,* biomass may be below a **target** reference point); **or** b. is estimated to be above a target reference point appropriate for the species (that is based on up-to-date life-history and spatial distribution information); **OR**	3.67

	2. Quantitative stock assessment is lacking, but there is a data-limited assessment available and there is confidence that the stock is healthy and no conflicting indicators[6] (see Appendix 7)	
Moderate	1. Species is above a limit reference point but below 75% of the target reference point; **OR** 2. When: a. there are no stock data available, **OR** b. there are no appropriate reference points, **OR** c. a data-limited assessment available and there is enough uncertainty that there is little confidence in the result, **OR** d. data limited assessment methodologies provide conflicting conclusions, **SUCH THAT:** **e.** the Data Limited Stock Assessment Decision Tree (see Appendix 7) requires that a Productivity Susceptibility Analysis be conducted, it is determined that the stock is NOT highly vulnerable; **OR** 3. Stock is classified by management body as not overfished or has IUCN Least Concern status; **OR** 4. For forage species, stock biomass is above the limit reference point, but reference points are not, or it is unknown whether they are, appropriate for the species.	2.33
High	1. Probable that the stock is below the limit reference point, depleted/overfished, or determined to be a stock of concern, vulnerable, endangered or threatened by a state, national, or international scientific body (including COSEWIC designations of Endangered or Threatened and IUCN listings of Critically Endangered, Endangered, Vulnerable or Near	1

[6] Guidance on "appropriate data-limited assessment methods" to be developed. Until that time, Appendix 7 is provided to illustrate examples only and these indicators and thresholds should not be assumed to be appropriate for all fisheries. Data and assessments to be provided by the fisheries and verified by expert input. See also "recent stock assessment" definition for guidance on consideration of the currency of data-limited assessments.

	Threatened; however, more recent or more regional/stock specific data can override these determinations); **OR** 2. One or more available appropriate data-limited assessment method(s) (see Appendix 7) suggest status of stock is poor; **OR** 3. When; a. there are no stock data available, **OR** b. there are no appropriate reference points, **OR** c. a data-limited assessment available and there is little confidence in the result due to high uncertainty, **OR** d. data limited assessment methodologies provide conflicting conclusions, **SUCH THAT:** e. the Data Limited Stock Assessment Decision Tree (see Appendix 7) requires that a Productivity Susceptibility Analysis be conducted, it is determined that the stock is highly vulnerable.	

Known but data-limited species

In cases where bycatch species are known but not formally assessed: when a given species has no formal stock assessment but there are at least two appropriate data-limited assessments to indicate stock status (See Appendix 7 for examples of appropriate data-limited assessments), stock abundance should be assessed as in Factor 1.1. If there are no appropriate data-limited methods that can be used to indicate stock status, follow guidance for "unassessed species" below.

Unassessed species

In cases where bycatch species are known, but there is no indication of stock status (for example, there is no formal stock assessment or data-limited assessment), group species by taxon and use the Unknown Bycatch Matrices to score each group. Specific bycatch species should be listed in the text, and care should be taken to ensure that species likely to be of higher vulnerability are given appropriate consideration.

Unknown bycatch composition

In cases where bycatch composition is unknown or data-limited, use the Unknown Bycatch Matrices to assess the likely bycatch species (as defined by using the instructions for "identifying unknown species" under "main species").

To use the Unknown Bycatch Matrices:

1. Determine which taxa to include: begin by considering each taxon listed in Appendix 2/Unknown Bycatch Matrices for this type of fishery with a score of **3.5 or below**. This list can be adjusted as appropriate taking into account conditions of the particular fishery. When bycatch species are known, all taxa that include species that meet the 'main species' threshold should be scored.

2. Score Factor 2.1 as "high concern" if the taxon is comprised largely of species that are either:
   a. Of high vulnerability (*i.e*., sharks, sea turtles, marine mammals, seabirds, and coral, as well as families or genera of fish or invertebrates that are known to have high vulnerability (see list in Appendix 2),
   b. Unassessed in the fishery area, but closely related species or neighboring stocks of known status are generally of "high concern," or
   c. Are overfished, endangered or threatened within the range of the fishery

   Note: The score of "high concern" can be overridden based on data that indicate a particular species is not highly vulnerable or a specific fishery is operating differently from the standard operating procedures.

3. Score Factor 2.1 as "moderate concern" for teleost fish or invertebrates that are not from highly vulnerable taxa as defined in #2 above.

Factor 2.2 Fishing Mortality

Goal: *Fishing mortality is appropriate for the current state of all main bycatch species/stocks.*

Known species

NOTE: Rankings are based on fishing mortality/exploitation rate, e.g., F/F_{MSY}. For the purposes of this table, a stock is deemed "not depleted" if ranked as "very low" to "moderate" conservation concern under 2.1; and is deemed "depleted" if ranked as "high" conservation concern under 2.1. When determining whether a fishery is a substantial contributor, and/or whether fishing mortality is at or below a sustainable level, err on the side of caution when there is uncertainty. For further guidance, see Appendix 1 (guidance on evaluating fishing mortality).

Table 2.2.1: Scoring guidelines for fishing mortality on associated species.

Conservation Concern	Description	Score
Low Concern	1. Probable (>50% chance) that fishing mortality from all sources (including commercial, recreational, subsistence, and ghost fishing, if applicable) is at or below a sustainable level that is appropriate for the species (*i.e.,* a level that will allow a population to maintain abundance at or rebuild to B_{MSY} or a suitable proxy); **OR**	5

	2. Species is non-native; **OR** 3. For species assessed under C2: Fishery is not a substantial contributor to fishing mortality or its contribution to mortality is expected to be low enough to not adversely affect population.	
Moderate Concern	1. F is fluctuating around a reference point that is appropriate for the species; **OR** 2. F is above a target reference point and below a limit reference point that is appropriate for the species[7]; **OR** 3. Unknown[8]; **OR** 4. F is below reference points and appropriateness of reference points is unknown. This includes most forage species, unless overfishing is occurring, or there is evidence that fishing mortality is below a reference point that is appropriate for the species.	3
High Concern	1. Probable (>50% chance) or suspected that fishing mortality from all sources (including commercial, recreational, subsistence, and ghost fishing, if applicable) is above a sustainable level that is appropriate for the species (*i.e.,*a level that will allow a population to maintain abundance at or rebuild to B_{MSY} or a suitable proxy) (*e.g.*, overfishing is occurring); **AND** 2. For species assessed under Criterion 2: individual fishery's contribution is unknown or fishery is a substantial contributor.	1

Marine Mammals in U.S. Fisheries

Additional guidance for scoring of marine mammals caught in U.S. fisheries is given below (due to the availability of data on potential biological removal (PBR) and fishing mortality rates on all bycaught marine mammals, available in marine mammal stock assessments and List of Fisheries reports, see https://www.fisheries.noaa.gov/national/marine-mammal-protection/list-fisheries-summary-tables)

[7] In this situation, the limit reference point should be set at the overfishing limit (or equivalent). If target reference point is set at the overfishing limit and is being exceeded, a score of "high concern" should be given.
[8] Where fishing mortality (F) is unknown, or where F is known but there are no available reference points to determine whether F is at an appropriate level.

If PBR or fishery mortality relative to PBR is not known, score conservatively given what is known (e.g., fishery and/or species classification) or score as “moderate.” Example: if it is unknown but fishery is classified as Category II and species is not strategic, score as “low” (see https://www.fisheries.noaa.gov/laws-and-policies/glossary-marine-mammal-protection-act, US U.S.C. 136219)).

Use Table 2.2.2.b to score marine mammals caught in non-U.S fisheries that are on the List of Foreign Fisheries (LOFF). Assess marine mammals in non-U.S. fisheries that are NOT listed in the LOFF similarly, scoring “low concern” when evidence shows the fishery is not negatively impacting the recovery/stability of the marine mammal population.

Table 2.2.2.a: Scoring guidelines for fishing impacts on marine mammals in US fisheries

% of PBR taken by fishery	Cumulative fisheries mortality > PBR?	Seafood Watch Rating
<50%	No	Low
50-100%	No	Moderate
<10%	Yes	Low
10-50% and not one of the main contributors to total mortality	Yes	Moderate
>50% OR a main contributor to total fisheries-related mortality	Yes	High

Table 2.2.2.b. Scoring guidelines for fishing impacts on marine mammals in non-US fisheries.

LOFF Category	Presence of injury or mortality (P/A in LOFF)?	Seafood Watch Rating
Exempt	No	Not included
	Category III	Low concern
Export	No or unknown	Use the UBM
	Yes	Score as you would score a U.S. fishery with no PBR described below

Unknown or data limited species

If a Productivity-Susceptibility Analysis is used to score abundance for species with no abundance and fishing mortality data, use Table 1.2.1 to score fishing mortality for that species (this will most likely result in a score of “moderate” for unknown fishing mortality). If bycatch includes marine mammals, sea turtles, seabirds and/or highly vulnerable sharks, and there is no assessment of the fishery’s impact on these species, use the Unknown Bycatch Matrix (UBM) to score fishing mortality for these species. Where bycatch species are not fully known, but taxonomic groups at risk are known or can be inferred, group species by taxon and use the UBM to score each group. Note that the UBM score can be overridden if the evidence suggests that bycatch species caught in the particular fishery being assessed are not of “high concern.”

Taxa identified using the Unknown Bycatch Matrices should be scored according to the table in Appendix 2 and the table below. As with determining main species and scoring abundance, if there are data that indicate a specific fishery is operating differently from the standard operating procedures, the Unknown Bycatch Matrices can be overruled.

Table 2.2.3: Scoring guidelines for fishing impacts on unknown taxa.

Bycatch score from Unknown Bycatch Matrices (1–5)	Fishing Mortality
>=3.5	Low Concern
2.5-3	Moderate Concern
1-2	High Concern

Factor 2.3 Modifying Factor: Discards and Bait Use

Goal: *Fishery optimizes the utilization of marine resources by minimizing post-harvest loss and by efficiently using marine resources as bait.*

Overview: While the rest of Criterion 2 focuses on the population impacts on bycatch and other capture species, Factor 2.3 addresses the issue of the waste associated with high discards or bait use in capture fisheries. The score is adjusted downward based on high discards + bait use and the color rating of Criterion 2 is affected accordingly.

Because bait use is considered in 2.3 but is rarely quantified, we aim to provide default scores for bait use, based on literature review, for a variety of fishery types (target species and gear). We will provide an opportunity to override these default scores if data specific to the fishery can be provided.

Instructions: This weighting factor is addressed once for each fishery under assessment. Both bait and dead discards are considered relative to total landings. This ratio refers to the total dead discards and/or bait use relative to total landings **of all species** caught in the fishery. The discard mortality rate is generally assumed to be 100% (i.e., all discards count as dead discards). Exceptions include cases where research has demonstrated high post-release survival, including invertebrates caught in pots and traps. Research that demonstrates high post-release survival for the same or similar species caught with the same or comparable gear types may qualify as showing high post-release survival. When discard mortality rates are known, multiply these rates by the amount of discards for the relevant species to determine the amount of dead discards. If the bycatch:landings ratio and/or bait use are unknown, refer to average bycatch rates for similar fisheries (based on gear type, target species and/or location) as given in review papers (e.g., Kelleher 2005 and Alverson et al. 1994). Bait use, if unknown, need only be addressed in cases where it is likely to be substantial relative to landings (e.g., lobster pot fishery). Err on the side of caution when there is no information.

If the amount of dead discards plus bait use relative to total *landings* (in biomass or numbers of fish, whichever is higher) exceeds 100% (i.e., discards plus bait exceeds landings), modify the total score for Criterion 2 by multiplying by a factor of 0.75. Other fisheries are unaffected (given a score of 1).

Table 2.3.1: Scoring guidelines for fishery discards and bait use.

Ratio of bait + discards/landings	Factor 2.3 score
< 100%	1
>=100%	0.75

Criterion 2 Score and Rating

Criterion 2 Score for the stock for which you want a recommendation = Subscore * Discard Rate (Factor 2.3).

- Subscore = lowest score of all other assessed species caught.
    - Score for each species = geometric mean (Factors 2.1, 2.2). Rating is based on the lowest **Score** as follows:

- >3.2 = **Green**
- >2.2 and <=3.2 = **Yellow**
- <=2.2 = **Red**

Criterion 3 – Effectiveness of Fishery Management

Guiding principles

The fishery is managed to sustain the long-term productivity of all impacted species. Management should be appropriate (see Appendix 3 for more guidance) for the inherent vulnerability of affected marine life and should incorporate data sufficient to assess the affected species and manage fishing mortality to ensure little risk of depletion. Measures should be implemented and enforced to ensure that fishery mortality does not threaten the long-term productivity or ecological role of any species in the future.

Goals: *Management strategy has a high chance of preventing declines in stock productivity by taking into account the level of uncertainty, other impacts on the stock, and the potential for increased pressure in the future. See Appendix 3 for more guidance.*
Management strategy prevents negative population impacts on bycatch species, particularly species of concern.

Assessment instructions

Assess Factors 3.1 through 3.5 once for each fishery. See table below to calculate final C3 score.
For fisheries that catch multiple SMUs and release fish from some SMUs, management of SMUs that are retained should be considered in factor 3.1, while management of released SMUs should be considered in 3.2. Where there are encounters with minor SMUs within the fishery, management measures to limit fishing mortality should be considered in factor 3.1, while management measures aimed at avoiding capture (e.g., spatial and temporal closures) or ensuring minimal harm (e.g., live release) should be considered in factor 3.2.

Step 1: Assign a rating for each of the five management subfactors using the table below:

Factor 3.1 Management Strategy and Implementation

Table 3.1: Scoring guidelines for fisheries management strategy and implementation.

3.1 Management strategy and implementation	**Description**
Highly Effective Goal: Fishery has highly appropriate strategy and goals and there is evidence that the strategy is being	1. For a fishery targeting a single SMU, **or** for more than 70% of a multi-species/SMU fishery's main, native species/SMUs (by number), appropriate management/conservation targets have been defined (*e.g.*, reference points); **AND** 2. For a fishery targeting a single SMU, **or** for more than 70% of a multi-species/SMU fishery's main, native species/SMUs (by number), management has implemented precautionary policies that are based on scientific advice and which incorporate uncertainty and environmental variability; are characteristic of flexible and resilient

implemented successfully	fisheries management with risk aversion in place; include regulations to control fishing mortality, prevent localized depletions, and respond within appropriate timeframes[9] to the state of the stock nationally and internationally (see Appendix 3 for examples of highly effective management strategies); **AND** 3. Effective strategies are in place for targeted/retained **overfished, depleted, endangered or threatened** species that will allow for recovery with a high likelihood of success in an appropriate timeframe; **AND** 3. There is evidence that the strategy is being implemented successfully; **AND** 4. Management is responsive to changes in stock productivity and/or biomass; **AND** 5. Harvest control rules include conservative buffers appropriate for the species that are accepted without scientific controversy and are demonstrated to be effective; **OR** 7. For NON-NATIVE species, a. strategies are in place that: 1) prevent further spread of and reduce biomass over time or suppress biomass to low levels (*e.g.*, below B_{MSY} or suitable proxy); **or** 2) include mechanisms to allow for recovery of species impacted by the non-native; **AND** b. Management does not exacerbate concern with the non-native, *e.g.,* through stocking or seeding.
Moderately effective	Fishery does not meet all the standards of "highly effective" management; **but**

[9] When determining an appropriate timeframe it is important to consider the ability of managers to adjust management measures to take into account the latest scientific information and advice, for example, if a stock assessment identifies that overfishing took place in the previous fishing season, do managers adjust the harvest controls for the upcoming season?

	1. For a fishery targeting a single SMU, **or** for more than 70% of a multi-species/SMU fishery's main, native species/SMUs (by number), management measures in place still exceed those for "Ineffective" or "Critical" management; **AND** 2. For a fishery targeting a single SMU, **or** for more than 70% of a multi-species/SMU fishery's main, native species/SMUs (by number), management measures in place are expected to be effective (see Appendix 3), **but**: a. There is a need for increased precaution (*e.g.*, stronger reductions in TAC when biomass declines, quicker reaction to changes in populations, etc.); **OR** b. Effectiveness is unknown and it is UNLIKELY that the fishery is having serious negative impacts on any retained populations (*e.g.*, statuses of all main retained populations are known and none are scored red); **OR** c. Measures have not been in place long enough to evaluate their success; **OR** d. There is uncertainty regarding implementation of the management measures in place, but the instruments to ensure effective implementation exist (e.g. relevant national, regional and local legislation) and there is no evidence of systematic non-compliance. **AND** 3. Species of Concern, and Overfished or Depleted Stocks a. For all targeted/retained species that are overfished or depleted, management has a rebuilding or recovery strategy in place whose eventual success is probable; **OR** b. Best management practices to minimize mortality of "stocks of concern" are implemented and are believed to be effective; **AND** 4. Non-Native Species

<table>
<tr><td></td><td>a. Management measures or harvesting prevent increases in stock size and further spreading; AND
b. If any stocking or seeding occurs, species is already established, and ongoing stocking/seeding activity has been demonstrated not to contribute to growth or spread of non-native population.</td></tr>
<tr><td>Ineffective</td><td>Management exceeds the standard of “critical” below, but:

1. Management effectiveness is unknown, and it is LIKELY that the fishery is having serious negative impacts on retained populations (e.g., Criterion 1 and/or Criterion 2 is scored red due to concerns with the status of one or more main retained populations);

OR

2. There is uncertainty regarding implementation of the management measures in place and the necessary instruments to ensure effective implementation are lacking (e.g. relevant national, regional and local legislation) or there is evidence of systematic non-compliance;

OR

3. There is no management and it is UNLIKELY that the fishery is having serious, negative impacts on any retained populations (e.g., statuses of all main retained populations are known and none are scored red);

OR

4. Management sets catch limits above scientifically recommended levels, or otherwise disregards scientific advice;

OR

5. The fishery lacks management measures that are reasonably expected to be effective, appropriate strategies for rebuilding species of concern, or appropriate control of non-native fished species (where applicable) as detailed under “moderately effective” (#2-5) above.</td></tr>
<tr><td>Critical</td><td>1. Management strategy is insufficiently precautionary to protect retained populations or strategies have not been implemented successfully;

OR</td></tr>
</table>

	2. There is no management where clearly needed; **OR** 3. The fishery targets and/or regularly retains overfished, depleted, endangered or threatened species, the fishery is a substantial contributor to mortality of the species, and management lacks an adequate rebuilding or recovery strategy and/or effective practices designed to limit mortality of these species (for example, overfishing is occurring); **OR** 4. For non-native species, there are known or likely negative impacts on the ecosystem, fishery is maintained in part through stocking/seeding/etc., and/or stock size or further spread are not controlled by harvesting or other strategies; **OR** 5. Fishery management does not comply with relevant legal requirements; **OR** 6. Substantial Illegal fishing; 25% or more of the product is caught illegally.

Factor 3.2 Bycatch Strategy

Table 3.2: Scoring guidelines for bycatch management strategy and implementation.

3.2: Bycatch Strategy	**Description**
Highly Effective	Fishery has no or very low (<5%) bycatch[10] (including any unintended or unmanaged catch, even if retained), with no bycatch of species or stocks of concern; **or** IF species of concern are caught **or** the fishery is not highly selective (*i.e.*, rate of discards, non-target or unmanaged catch exceeds 5% of landings): 1. The fishery has a highly effective or precautionary strategy and goals designed to minimize the impacts of the fishery on bycatch species; **AND**

[10] For the purposes of a Seafood Watch assessment of salmon fisheries, bycatch can include discarded salmon of the same species as those being retained. This typically happens in mark-selective fisheries. The release of salmon, especially when there is a high likelihood of post-release survival, should be considered a bycatch management strategy under factor 3.2.

	2. There is evidence that either a. the strategy is being implemented successfully (*e.g.*, there is a well-known track record of consistently setting conservative bycatch limits based on quality information and advice about bycatch); **or** b. bycatch is minimized to the greatest extent possible, especially for vulnerable species such as sharks, seabirds, turtles, and marine mammals, through mitigation measures that have been shown to be highly effective (see Appendix 4 for guidance); **AND** 3. Fishery is not a leading cause of a high level of mortality for any species of concern (*e.g.*, not a Category I fishery for marine mammal bycatch); **AND** 4. If a fishery has a demonstrated concern with or a significant likelihood of ghost fishing (of target or non-target species), there is a comprehensive strategy to address ghost fishing that includes the following: a. measures to assess, prevent, mitigate and remove the impacts of derelict gear from the fishery (*e.g.*, gear modifications, gear-tending procedures, etc.), **and** b. a time-sensitive requirement for reporting gear loss and location
Moderately Effective	IF species of concern are caught **or** the fishery is not highly selective (*i.e.,* rate of discards, non-target or unmanaged catch exceeds 5% of landings), The fishery must have some bycatch management measures in place to meet the "moderately effective" threshold (including implementing an appropriate Take Reduction Plan for U.S. fisheries listed as Category I for marine mammal bycatch, and measures to mitigate ghost fishing if there is a demonstrated concern with or high likelihood of ghost fishing), **BUT either** 1. The strategy or implementation effectiveness is under debate or uncertain (*e.g.*, bycatch limits are imposed based on assumptions, but limits are disputed or unsure); **OR** 2. Bycatch reduction techniques are used but are of unknown or uncertain effectiveness; **OR**

	3. Management has not been in place long enough to evaluate its effectiveness or is unknown; **OR** 4. Where applicable, prevent, mitigate or remove ghost gear.
Ineffective	IF species of concern are caught or the fishery is not highly selective (*i.e.,* rate of discards, non-target or unmanaged catch exceeds 5% of landings): 1. The bycatch management measures are insufficient given the potential impacts of the fishery (*e.g.*, fishery has bycatch of species of concern or a high discard rate and does not implement best practice measures for all such species, evidence to show that U.S. MMPA Take Reduction plan is ineffective); **OR** 2. There is strong evidence that shark finning is taking place in this fishery; **OR** 3. Fishery does not comply with all relevant legal requirements regarding bycatch; **OR** 4. If a fishery has a demonstrated concern with or high likelihood of ghost fishing (of target or non-target species), management measures are insufficient to prevent, mitigate or remove potential ghost fishing, or are non-existent; **OR** 5. If management of a fishery used to supply bait being used in the fishery under assessment is known to be poor (for example the fishery is rated as “Avoid” and/or management is scored as “Ineffective” by Seafood Watch).

Factor 3.3 Scientific Data Collection and Analysis

Table 3.3: Scoring guidelines for scientific research and monitoring of fisheries.

3.3: Scientific Data Collection and Analysis	Description
Highly Effective	1. The management process uses an independent and up-to-date scientific stock assessment or analysis, or other appropriate method that seeks knowledge related to stock status; **AND** 2. This assessment is complete and robust, is peer reviewed by a scientific body, includes all major, relevant sources of fishing mortality (*e.g.*, recreational fishing), and contains both fishery-independent data, including abundance data, and appropriate fishery-dependent data; **AND** 3. Abundance and geographic range of any non-native target species are monitored; **AND** 4. Bycatch is appropriately monitored; **AND** 5. Adequate observer coverage or effective video monitoring coverage, and data collection and analysis are sufficient to ensure that goals are being met for both bycatch and retained species; **AND** 6. Fisheries with a potential for ghost fishing impacts, including pot/trap and gillnet (and other fisheries employing gears which have demonstrated ghost gear impacts), must collect data on lost gear or otherwise demonstrate a strategy to include ghost fishing impacts in the assessment of fishing mortality; **AND**

	7. For forage species, stock assessments are conducted with sufficient frequency to account for their dynamic nature and recognize fluctuations in biomass and/or productivity.
Moderately Effective	1. Some data related to stock abundance and health are collected and analyzed. Data may not be sufficient to meet "highly effective" category, but are used to monitor and maintain the stock using appropriate data-limited assessment methods and management strategies; **OR** 2. Management relies on an appropriate strategy that requires only minimal monitoring (*e.g.*, large protected areas including spawning habitat, and other appropriate "data-less" management techniques);
Ineffective	1. No data or very minimal data are collected or analyzed; appropriate data-limited assessment and management methods are not used (see Appendix 7); **OR** 2. Bycatch is not monitored or assessed and fishery is not using a highly selective gear; **OR** 3. The fishery's main targeted species are unassessed and regulations to constrain fishing mortality for these species are lacking.

Factor 3.4 Enforcement of and Compliance with Management Regulations

Table 3.4: Scoring guidelines for enforcement of fisheries management regulations.

3.4: Enforcement of and Compliance with Management Regulations	**Description**
Highly Effective	1. The appropriate permits, regulations, requirements of biological opinions, (or equivalent documents for non-U.S. fisheries) and agreed-upon, voluntary arrangements are regularly enforced and independently verified, including VMS, logbook reports, dockside surveillance and other similar measures appropriate to the fishery;

	AND 2. Capacity to control, ensure, and report compliance are appropriate to the scale of the fishery including the detection and prevention of illegal fishing; **AND** 3. If applicable, 100% of at-sea transshipments must be observed.
Moderately Effective	Enforcement and/or surveillance are in place to ensure goals are successfully met, although effectiveness of enforcement/ surveillance may be uncertain (*e.g.*, regulations are enforced by fishing industry or by voluntary/honor system, but without regular independent scrutiny).
Ineffective	Enforcement and/or surveillance is lacking or believed to be inadequate, or compliance is known to be poor.

Factor 3.5 Stakeholder Inclusion

Table 3.5: Scoring guidelines for stakeholder inclusion in the fisheries management process.

3.5: Stakeholder Inclusion	**Description**
Highly Effective	The management process is transparent and includes stakeholder input, which means managers: 1. Involve all user groups; **AND** 2. Provide a mechanism to effectively address user conflicts; **AND** 3. Encourage high participation in both the assessment and management process; **AND** 4. Make transparent decisions; **AND** 5. There is an effective and constructive relationship between managers, scientists, and fishermen.

Moderately Effective	1. The management process is transparent and includes stakeholder input; **BUT** 2. All user groups are not effectively considered, or user conflicts are not effectively resolved.
Ineffective	1. Stakeholders are not included in decision-making; **OR** 2. Decisions are not made transparently

Step 2: Assign a rating and a score for management effectiveness (Criterion 3) based on the five factors rated above.

Table 3.6: Scoring guidelines for criterion 3, fisheries management.

Conservation Concern:	Description	Score
Very Low	Meets or exceeds the standard of "highly effective" management for all five factors	5
Low	1. Meets or exceeds all the standard for "moderately effective" management for all five subfactors; **AND** 2. Meets or exceeds the standard of "highly effective" management for, at a minimum, both "management strategy and implementation" and "bycatch management"; **BUT** 3. At least one other factor is not "highly effective."	4
Moderate	1. Meets or exceeds all the standards for "moderately effective" management for all five subfactors; **BUT** **2.** Either "management strategy and implementation" or "bycatch management" is not "highly effective."	3
High	1. Meets or exceeds the standard for "moderately effective" management for, at a minimum, "management strategy and implementation" and "recovery of stocks of concern";	2

	BUT 2. At least one other factor is "ineffective."	
Critical	1. "Management strategy and implementation" and/or "bycatch management" are "ineffective"; **OR** 2. Fishery uses explosives or poison, *e.g.*, cyanide.	1

Note: a score of "1" (Critical) for Management results in an "Avoid" ranking overall.

Criterion 3 Score and Rating

Rating is based on the Score for Criterion 3 as follows:

- **Green** if >3.2
- **Yellow** if >2.2 and <=3.2
- **Red** if > 1 and <=2.2

Rating is **Critical** if scored a 1.

Criterion 4 – Impacts on the Habitat and Ecosystem

Guiding principles
Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs. The fishery does not adversely affect the physical structure of the seafloor or associated biological communities.

If high-impact gears (e.g. trawls, dredges) are used, vulnerable seafloor habitats (e.g. corals, seamounts) are not fished, and potential damage to the seafloor is mitigated through substantial spatial protection, gear modifications and/or other highly effective methods.

Maintain the trophic role of all marine life. All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web, as informed by the best available science.

Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts. Fishing activities must not result in harmful changes such as depletion of dependent predators, trophic cascades, or phase shifts.

This may require fishing certain species (e.g., forage species) well below maximum sustainable yield and maintaining populations of these species well above the biomass that produces maximum sustainable yield.

Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks. Any enhancement activities are conducted at levels that do not negatively affect wild stocks by reducing diversity, abundance or genetic integrity.

Management of fisheries targeting enhanced stocks ensure that there are no negative impacts on the wild stocks, in line with the guiding principles described above, as a result of the fisheries.

Follow the principles of ecosystem-based fisheries management. The fishery is managed to ensure the integrity of the entire ecosystem, rather than solely focusing on maintenance of single species stock productivity. To the extent allowed by the current state of the science, ecological interactions affected by the fishery are understood and protected, and the structure and function of the ecosystem is maintained.

Assessment instructions
Address Factor 4.1–4.2 for all fishing gears separately. Assess Factor 4.3 once per fishery.

Factor 4.1 Physical Impact of Fishing Gear on the Habitat/Substrate

Goal: *The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.*

Instructions: Fishing gears that do **not** contact the seafloor score 5 for this criterion, and Factor 4.1b can be skipped. Use the table below to assign a score for gear impacts (Appendix 5 provides further guidance). If gear type is not listed in the table, use the score for the most similar gear type in terms of extent of bottom contact. Seafood Watch will not assess a fishery using destructive gear such as explosives or cyanide regardless of habitat type and management actions; therefore, those fishing methods are not included in the table. Where multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, score conservatively according to the most sensitive plausible habitat type. See Appendix 5 for further guidance and the methods used in developing the table below.

Table 4.1.1: Scoring guidelines for fishing impacts on aquatic habitats.

Description	Seafood Watch score
Gear does not contact bottom; fishing for a pelagic/open water species	5
1. Vertical line fished in contact with the bottom; **or** 2. Fishing for a benthic/demersal or reef-associated species	4
1. Bottom gillnet, trap, bottom longline except on rocky reef/boulder and corals; **or** 2. Bottom seine (on mud/sand only); **or** 3. Midwater trawl that is known to contact bottom *occasionally* (<25% of the time) **or** purse seine known to commonly contact bottom	3
1. Scallop dredge on mud and sand; **or** 2. Bottom gillnet, trap, bottom longline on boulder or coral reef; 3. Or known trampling of coral reef habitat occurs; **or** 4. Bottom seine (except on mud/sand); **or** 5. Bottom trawl (mud and sand, or shallow gravel) (includes midwater trawl known to commonly contact bottom)	2
1. Hydraulic clam dredge; **or** 2. Scallop dredge on gravel, cobble or boulder; **or** 3. Trawl on cobble or boulder, or low energy (>60 m) gravel; **or** 4. Bottom trawl or dredge used primarily on mud/sand (or to catch a species that associates with mud/sand habitat), but information is limited and there is the potential for the gear to contact sensitive habitat	1
Dredge or trawl on deep-sea corals or other biogenic habitat (such as eelgrass and maerl)	0

Factor 4.2 Modifying Factor: Mitigation of Gear Impacts

Goal: *Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.*

Instructions: Assess Factor 4.1b only for fishing gear that contacts the bottom. Scores from Factor 4.1b can only improve the base score from 4.1a. A high level of certainty is required to score a strong or moderate mitigation measure, e.g., good quality seafloor maps, VMS and/or observer coverage is required to document that spatial measures are effective and enforced. Further guidance can be found in Appendix 6.

Assess the fishery management's efforts to mitigate the fishery's impact on the benthic habitat. **Factor 4.1b allows the habitat score to increase, based on the strength of mitigation measures, by the number of bonus points specified in the table.**

Table 4.2.1: Scoring guidelines for the mitigation of impacts of fishing gear on aquatic habitats.

1. At least 50% of the representative habitat is protected from the gear type used in the fishery under assessment (see Appendix 6); **OR** 2. a. For trawl/dredge fisheries, expansion of the fishery footprint into untrawled/undredged habitat is prohibited. A rotational strategy of habitat protection if deemed appropriate is acceptable); **AND** b. Fishing intensity is constrained to be sufficiently low. Must have scientific evidence (using knowledge of the resilience of the habitat and the frequency of fishing impacts from the gear type used in the fishery under assessment (see Appendix 5)), that at least 50% of the representative habitat is in a recovered state and will remain so under current management; **AND** c. Vulnerable habitats are strongly protected; **OR** 3. a. Gear is specifically designed to reduce impacts on the seafloor; **AND** b. There is scientific evidence that these modifications are effective; **AND** c. Gear modifications are used on the majority of vessels **OR** 4. Other measures are in place that have been demonstrated to be highly effective in reducing the impact of the fishing gear, which may include an effective combination of both "moderate" measures described below, e.g., gear modifications + spatial protection.	+1
1. a. A substantial proportion of all representative habitats are protected from all bottom contact; **AND** b. For trawl/dredge fisheries, expansion of the fishery's footprint into untrawled/undredged habitat is prohibited (note: this does not prohibit a rotational strategy of habitat protection if deemed appropriate); **AND** c. Vulnerable habitats are strongly protected; **OR** 2. Gear modifications or other measures are in use that are reasonably expected to be effective.	+0.5
Does not meet standard for +0.5 above, or	+0

Not applicable because gear used is benign and fishery received a score of “5” for 4.1a.	+0

Scoring for Factor 4.1: Impact on the Habitat

The score for Factor 4.1 is the sum of the score for 4.1 and the score for 4.2. The category name for 4.1 is assigned based on score ranges, as below:

Table 4.2.2: Scoring categories for factor 4.1.

Score (Sum of 4.1 and 4.2)	**Category**
>3.2	Low Concern
>2.2 and ≤3.2	Moderate Concern
≤2.2	High Concern

Factor 4.3 Ecosystem-based Fisheries Management

Goal: *All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web.* Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

Instructions: Assign an ecosystem-based management score for the fishery. Habitat restoration efforts can be considered when scoring this factor (see Appendix 8 for further guidance).

Table 4.3: Scoring guidelines for ecosystem-based fisheries management.

Conservation Concern	Description	Score
Very Low	1. a. There are policies in place (e.g. harvest control rules) that are effective at protecting ecosystem functioning and accounting for species' ecological role; **and** b. Precautionary and effective spatial management is used, *e.g.* to protect spawning areas, prevent localized depletion, and protect important foraging areas for predators of fished species, if applicable; **OR** 2. An ecosystem study has been conducted and it has been scientifically demonstrated that the fishery has no unacceptable ecological and/or genetic impacts; **AND** 3. For fisheries on non-native species, policies in place to manage the fishery and/or control the spread of the species do not have long-term, adverse effects on native species.	5
Low	1. a. Policies are in place to protect ecosystem functioning and account for capture species' ecological role but have not yet proven to be effective; **and** b. Spatial management is used to protect ecosystem functioning; **AND** 2. For fisheries on non-native species, policies in place to manage the fishery and/or control the spread of the species do not have long-term, adverse effects on native species.	4
Moderate	1. The fishery lacks spatial management or other policies to protect ecosystem functioning and account for capture species' ecological role **but** detrimental food web impacts are not likely; **OR** 2. For fisheries on non-native species, the policies to manage the fishery and/or control the spread of the non-native species have an unknown effect on native species.	3
High	1. a. The fishery lacks spatial management or other policies to protect ecosystem functioning and account for capture species' ecological role; **and**	2

	b. The likelihood of trophic cascades, alternative stable states, or other detrimental food web impacts resulting from the fishery are high, but conclusive scientific evidence specifically related to the fishery are lacking; **OR** 2. For fisheries on non-native species, policies in place to manage the fishery and/or control the spread of the species have adverse effects on native species.	
Very High	Scientifically demonstrated trophic cascades, alternate stable states, or other detrimental food web impacts are resulting from the fishery.	1

Criterion 4 Score and Rating

Score = Geometric Mean (Factors 4.1a+4.1b, Factor 4.2)

Rating is based on the Score as follows:

- >3.2 = **Green**
- >2.2 and ≤3.2 = **Yellow**
- ≤2.2 = **Red**

Criterion 5X – Impact of Artificial Production

Guiding Principles:
Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity or genetic integrity of wild stocks. Any enhancement activities are conducted at levels that do not negatively affect wild stocks by reducing diversity, abundance, productivity or genetic integrity. Management of fisheries targeting enhanced stocks (i.e., SMUs that include hatchery-origin fish) ensures that there are no negative impacts on the wild stocks, in line with the guiding principles described above, as a result of the fisheries. Enhancement activities do not negatively affect the ecosystem through density dependent competition or any other means, as informed by the best available science.

Assessment Instructions:
This criterion (5X) is defined as an exceptional criterion that may not be relevant to all salmon fisheries, yet it can be a significant concern for those fisheries where influence from artificial production exists.

This criterion should be assessed for all fisheries that catch and retain salmon that originate from artificial production systems.

Factor 5.1 Impact of Artificial Production on Wild Populations

Goal: *Impacts of any artificial product are minimized to ensure the stability or recovery of wild populations within their natural range.*

Instructions: This factor is used to score the risk of negative impacts on wild salmon populations by artificial production. Use tables 5.1.2 and 5.1.3 as guidance to assign scores according to table 5.1.1. Juvenile salmon released from hatcheries may be available for harvest 1-5 years later, based on variable age-at-maturity among and within species. In the time between release and harvest, hatchery practices may change. Therefore, to be most relevant when determining the risk to wild salmon populations, analysts should consider current hatchery production data (rather than the hatchery practices when the harvested fish were released). Additional guidance can be found in Appendix 8.

Table 5.1.1: Scoring guidelines for the impact of artificial production on wild salmon.

Conservation Concern	Description	Score
Very Low Concern	Evidence to demonstrate that there are no negative impacts[11] of hatcheries associated with SMUs caught in the fishery on local naturally spawning populations.	5
Low Concern	More than 70% of the major SMUs caught in the fishery demonstrate: 1. No artificial production;	4

[11] A specific study has been conducted and it has been scientifically demonstrated that artificial production program has no negative ecological or genetic impact on wild populations.

	OR 2. Impacts of artificial production are minor; **OR** 3. A program-specific study has been conducted and it has been scientifically demonstrated that artificial production program has no negative ecological and/or genetic impacts; **AND** 4. No major SMUs caught in the fishery demonstrate major impacts or influence from artificial production.	
Moderate Concern	The requirements for "low concern" are not met **AND** More than 50% of major SMUs caught in the fishery demonstrate: 1. No artificial production; **OR** 2. Impacts/Influence of artificial production are minor or moderate; **OR** 3. A program-specific study has been conducted and it has been scientifically demonstrated that artificial production program has no negative genetic and/or ecological impacts.	3
High Concern	More than or equal to 50% of the major SMUs caught in the fishery demonstrate: Impacts/Influence of artificial production are major.	2

Very High Concern	There is evidence of significant negative impacts, e.g. complete replacement of wild population by hatchery origin fish on wild populations, as a result of hatcheries within the scope of the assessment.	1

Instructions for assessing risk of artificial production to wild salmon: There are two approaches that can be used to evaluate the risk of artificial production dependent on the information that is available as outlined in Table 5.1.2. In situations where data on proportion of hatchery origin spawners (pHOS) and proportion of natural origin broodstock (pNOB) are collected, the relative proportions should be used to provide an estimate of risk to wild populations. When such data are not available, an alternative approach to assessing the influence of hatchery production on wild stocks can be used (see Appendix 8 for additional guidance). A fishery under assessment may contain some SMUs where there are data on pHOS and pNOB, and others where there are no such data. In these situations, analysts should consider the intent of the standard as identified in Table 5.1.2 and determine which description best characterizes the fishery under consideration. Analysts should take into account the available data and information and determine the level of influence. All scoring should be supported by credible evidence that has tested any assumptions that have been made in management measures used to support a scoring decision.

Table 5.1.2: Guidelines for determining the risk of artificial production to wild salmon.

Severity	**Impact of artificial production**	**Influence of artificial production**
Minor	The pHOS for the majority of natural spawning populations (>50%) in the SMU is less than 1%; and these populations are representative of the productivity and genetic diversity within each SMU, thus protecting the majority of the genetic diversity and productive capacity (adapted from MSC Fisheries Standard v2.01, 2018); **AND** The pHOS in each SMU (considering all populations that contain hatchery-origin fish) should be relatively low and, for integrated hatchery programs, the pNOB should be relatively high. Thresholds are as follows (adapted from HSRG 2015): • For segregated hatchery programs, pHOS should be no more than 5%; and • For integrated hatchery programs, pHOS should be no more than 30% and pNOB should exceed pHOS by at least a factor of two.	Management strategies or policies are in place to minimize the influence of artificially produced fish on wild populations and to minimize the genetic impact where interactions do take place. There is scientific evidence that these policies are successful, for example, straying of hatchery fish has been demonstrated to be low within the SMU. Other examples that could be used to demonstrate a minor influence are: • A specific study has been conducted and it has been scientifically demonstrated that artificial production programs have minimal negative ecological and/or genetic impacts • Artificially produced fish represent <10% of the total (both wild and artificial) juvenile production. • Ecologically and/or genetically unique wild populations are unlikely to interact with naturally spawning artificially produced fish.

Moderate	The pHOS for the majority (>50%) of populations in each SMU is less than 5%; and these populations are representative of the productivity and genetic diversity within each SMU, thus protecting the majority of the genetic diversity and productive capacity (adapted from MSC Fisheries Standard v2.01, 2018). **AND** For those populations within each SMU that contain hatchery fish, pHOS and pNOB thresholds are as follows (adapted from HSRG 2015): • For segregated hatchery programs, pHOS should be no more than 10%; and • For integrated hatchery programs, pHOS should be no more than 30%, and pNOB should exceed pHOS.	Management strategies or policies are in place to minimize the influence of artificially produced fish on wild populations and to minimize the genetic impact where interactions do take place. Plausible arguments can be made that these policies are successful, for example, artificial production within the SMU is at a moderate level. Other examples that could be used to demonstrate a moderate influence are: • Artificially produced fish represent 10-25% of the total (both wild and artificial) juvenile production • Ecologically and/or genetically unique wild populations are unlikely to interact with naturally spawning artificially produced fish.
Major	Statements describing minor or moderate impacts above cannot be used to describe each SMU caught in the fishery.	There are no management strategies or policies in place to minimize the influence of artificially produced fish on wild populations; **OR** There are management strategies or policies in place to minimize the influence of artificially produced fish on wild populations; however, there is evidence that assumptions within the management strategy or policies are not holding true; for example, there is evidence of high stray rates where straying is not expected. Other examples of major influence are: • Artificially produced fish represent >25% of the total (both wild and artificial) juvenile production • Artificially produced fish are likely interacting with ecologically and/or genetically unique wild populations during spawning.

Factor 5.2 Management of Artificial Production

Goal: *Management strategies for artificial production systems associated with the fishery have a high probability of preventing negative impacts on natural spawning populations.*

Instructions:
Step 1: Assign a rating for each of the four management sub-factors using tables 5.2.1-5.2.4 below. Depending on the scope of the individual recommendation there may be a number of different artificial production operations in place, which may fall under the jurisdiction of different management agencies. In order to ensure Seafood Watch assessments are manageable, analysts should score the management of artificial production based on an average operation across the range of operations that produce fish

in each SMU caught within a particular fishery. Discussion in the text should include references to specific plans to provide examples, and demonstrate better performance or highlight particular concerns; however, scoring should consider the typical or average performance at the SMU level. When scoring each sub-factor, the effective implementation of management measures should be considered when determining whether the score is appropriate. Stock Management Units that do not contain artificial production should not be considered as part of this scoring. Management strategies to minimize the impacts of artificial production on wild populations may differ between SMUs; as such, the following scoring tables should be considered guidance and if other management strategies achieve the same goals they can be considered highly or moderately effective providing scientific justification can be made. Guidance of how to score each sub-factor is found in Appendix 8

Factor 5.2.1: Management Strategy and Implementation

Table 5.2.1: Scoring guidance for artificial production management strategy and implementation.

Management Strategy and Implementation	**Description**
Highly Effective	4. Management goals/targets are set for primary salmon populations[12] (see Appendix 8); **AND** 5. The purpose of artificial production systems is clearly identified; **AND** 6. The broodstock strategy is clearly identified; **AND** 7. Artificial production is supported by a self-sustaining broodstock; **AND** 8. Artificial production management strategies are founded on scientific assessment of the benefits and risks of the program; **AND** 9. Scientific assumptions are clearly identified, tested and proven to be correct; **AND**

[12] Where populations have not been given a primary, contributing or stabilizing designation (or similar), all populations must meet the requirements of primary populations to achieve the highest available scores.

	10. Scale of artificial production is appropriate to meet, but not exceed management goals, for example, the number of juvenile releases does not typically result in excess adults returning to the spawning grounds relative to abundance targets; **AND** 11. Strategy aims to maximize survival of artificially produced juveniles by implementing best practices (see Appendix 8 for guidance); **AND** 12. Management strategy, goals and performance against these goals are reviewed on a regular basis; **AND** 13. The strategy is flexible enough to adapt to emerging data, research and scientific understanding and there is evidence that management strategies implement changes in response to scientific research and monitoring.
Moderately Effective	1. The requirements for highly effective are not met; **AND** a. The purpose of artificial production systems is clearly identified; **AND** b. The broodstock strategy is clearly identified; **AND** c. Management strategy has clearly defined goals/targets; **OR** **2.** Management strategies aim to address the major concerns associated with artificial production and are expected to be effective, but conclusive evidence may be lacking.
Ineffective	1. Requirements for moderately effective or highly effective are not met; **OR** 2. There is no management strategy;

	OR 3. Management strategy is not founded on scientific research; **OR** 4. There is evidence that management strategies are not implemented effectively; **OR** 5. Artificial Production operations within the scope of the report are proven to have had (or are having) an unacceptable impact on wild salmon populations.

Factor 5.2.2: Research and Monitoring

Table 5.2.2: Scoring guidance for research and monitoring of impacts of artificial production.

Research and Monitoring	Description
Highly Effective	1. pNOB and pHOS are known and monitored annually where appropriate; **AND** 2. The contributions of artificially produced fish and natural origin fish to fisheries are known and measured regularly; **AND** 3. Research is conducted on a regular basis to test whether assumptions made within the management strategy continue to hold true; **AND** 4. Research is conducted to find solutions to known or expected problems (e.g. long-term productivity of wild stocks in the presence of hatchery origin fish);

	AND **5.** There is effective monitoring and reporting consistent with requirements of operating permits for artificial production systems (for example water quality, chemical use including antibiotics);
Moderately Effective	1. The requirements for highly effective are not met; **BUT** 2. The contributions of artificially produced fish and natural origin fish to fisheries are known and measured regularly; **AND** 3. Contribution of artificially produced fish to natural spawning escapement has been estimated with reasonable accuracy; **AND** 4. Research is conducted to test whether assumptions made within the management strategy hold true, but this may not be on a regular basis; **AND** 5. There is effective monitoring and reporting consistent with requirements of operating permits for artificial production systems (for example water quality, chemical use including antibiotics).
Ineffective	1. Requirements for moderately effective or highly effective are not met; **OR**

	2. Contribution of artificially produced fish to natural spawning escapement is unknown; **OR** 3. Monitoring and reporting is not consistent with requirements of operating permits for artificial production systems (for example water quality, chemical use including antibiotics).

Factor 5.2.3: Compliance and Enforcement

Table 5.2.3: Scoring guidelines for the compliance with and enforcement of regulations pertaining to artificial production.

Compliance and Enforcement	**Description**
Highly Effective	1. Artificial Production facilities are constructed and operated in compliance with environmental laws and regulations, which are supported by evidence, e.g. permits and licenses are publicly available; **AND** 2. Permits required for release of artificially produced fish and collection of broodstock are effectively enforced and compliance is known to be high.
Moderately Effective	1. There is evidence that hatcheries have the required permits and licenses; AND 2. There is enforcement of regulations and permits but effectiveness and/or compliance is unknown.
Ineffective	1. There is no enforcement of regulations; **OR** 2. There is evidence of non-compliance with local, regional or international regulations.

Factor 5.2.4: Ecosystem Based Management

Table 5.2.4: Scoring guidelines for ecosystem-based management of artificial production.

Ecosystem Based Management	Description
Highly Effective	Artificial Production management plans include policies and practices which are demonstrated to minimize impacts on marine, freshwater and terrestrial ecosystems. There is clear evidence of coordination and collaboration with other groups in implementing the plan, where appropriate.
Moderately Effective	Artificial Production management plans include policies and practices that are expected to minimize impacts on marine, freshwater and terrestrial ecosystems. There is some evidence of coordination with other groups in implementing the plan, where appropriate, although full collaboration may be absent.
Ineffective	1. There are no policies in place to protect marine, freshwater and terrestrial ecosystems; **OR** 2. There are demonstrated unacceptable impacts on marine, freshwater or terrestrial ecosystems associated with artificial production systems included within the scope of the assessment.

Step 2: Assign a rating and a score for artificial production management of impacts on natural spawning populations based on the sub-factors rated above.

Table 5.2.5: Scoring guidelines for Factor 5.2, management of artificial production.

Conservation Concern	Description	Score
Very Low Concern	Meets or exceeds the standard of “highly effective” for all four sub-factors.	5
Low Concern	Meets or exceeds the standards of “moderately effective” for all four sub-factors and meets standard of Highly Effective for management strategy and implementation.	3.67
Moderate Concern	Meets or exceeds the standards of “moderately effective” for all four sub-factors.	2.33
High Concern	Scores “ineffective” for one or more of the sub-factors	1

Criterion 5X Score and Rating

Score = Geometric Mean (Factors 5.1, Factor 5.2)

Rating is based on the Score as follows:

- >3.2 = **Green**
- >2.2 and ≤3.2 = Yellow
- ≤2.2 = **Red**

Overall Score and Final Recommendation

Final Score = [geometric mean (Criterion 1, Criterion 2, Criterion 3, Criterion 4) X [(Criterion 5 score x 0.05) +0.75]

The overall recommendation is as follows:

- **Best Choice** = Final Score >3.2, **and** either Criterion 1 or Criterion 3 (or both) is Green, **and** no Red Criteria, **and** no Critical scores

- Good Alternative = Final score >2.2, **and** no more than one Red Criterion, **and** no Critical scores, **and** does not meet the criteria for Best Choice (above)

- **Avoid** = Final Score <=2.2, **or** two or more Red Criteria, **or** one or more Critical scores.

Glossary

Adequate observer coverage:

Observer coverage required for adequate monitoring depends on the rarity of the species caught, with fisheries that interact with rare species requiring higher coverage. Similarly, species that are "clumped" instead of being evenly distributed across the ocean also require higher levels of coverage. In addition, fisheries using many different gear types and fishing methods require higher levels of coverage. Bias may also be introduced if some areas, gear and seasons of a fishery are not well sampled. For these reasons, the exact level of coverage required for a particular fishery depends on the distribution of a species within the fishery as well as its associated discard and target species (Babcock et al. 2003). The analyst will need to determine what level of observer coverage is adequate for the fishery of interest; coverage of 17–20% (or as high as 50% for rare species bycatch) may be required in some cases but may not be necessary in all cases.

Appropriate Quantitative Stock Assessment:

A stock assessment that has been peer reviewed and approved, for example through a scientific and statistical committee, and includes appropriate reference points which are not known to be less conservative than MSY-based approaches. There may be some uncertainty associated with such assessments; however, if they have been approved or accepted by peer reviewers, they can be considered quantitative. Stock assessments that do not meet this guidance would be considered data-limited approaches.

Appropriate reference points:

Determination of the appropriateness of reference points depends on two questions:

1) *Is the goal appropriate?* Appropriate biomass reference points are designed with the goal of maintaining stock biomass at or above the point where yield is maximized (*target reference points*; *TRP*s) and safely above the point where recruitment is impaired (*limit reference points*; *LRP*s). Ideally, biomass reference points aim to maintain stock biomass at levels that allow the stock to fulfill its role in the ecosystem. Fishing mortality reference points should be designed with the goal of ensuring that catch does not exceed sustainable yield and has a very low likelihood of leading to depletion of the stock in the future.

2) *Is the calculation of the reference points credible?* There may be a concern if reference points have been lowered repeatedly or if there is scientific controversy regarding the reference points or the calculations of biomass and fishing mortality relative to reference points.
See the guidance for each type of reference point below and in Appendix 1.

Target reference point: Reference points need to be evaluated on a case-by-case basis, but in general: Biomass target reference points (TRPs) below about B35% require strong scientific rationale. See Appendix 1 for more details. For salmon fisheries, the target reference point should be considered to be equal to the spawning escapement that produces Maximum Sustainable Yield (S_{MSY}).

Limit reference point: The point where recruitment would be impaired. Reference points need to be evaluated on a case-by-case basis, but in general: Biomass limit reference points (LRPs) should be no less than ½ BMSY, or ½ an appropriate target reference point such as B40%. LRPs below about B20% or ½ BMSY require strong scientific rationale. For salmon fisheries, the limit reference point proxy should be considered to be 50% of the spawning escapement goal. Where an escapement range is given, the LRP proxy should be calculated to be 50% of the midpoint of this range.

Spawning potential ratio/fraction of lifetime egg production (SPR/FLEP) reference point: The SPR/FLEP limit reference point should either be derived through scientific analysis to be at or above replacement %SPR for the species (the threshold level of SPR necessary for replacement) based on its productivity and S-R relationship (i.e., Mace and Sissenwine 1993), or should be set at about 35–40% of LEP. An exception can be made for species with very low inherent productivity (e.g., rockfish, sharks), in which case a reference point of 50–60% of LEP is more appropriate (Mace and Sissenwine 1993, Myers et al. 1999, Clark 2002, Botsford and Parma 2005).

Relevant reference point: Salmon stocks are managed to different reference points dependent on the region. Spawning reference points and escapement reference points are the most common and refer to the number of fish reaching spawning grounds or migrating past a particular monitoring site, respectively. Appropriate reference points for salmon should ensure long-term viability of the SMU before providing harvest opportunities. Total returns or catches may be used as an indicator of abundance in some areas; however, such management strategies are likely to have high levels of uncertainty and extra precaution should be used when scoring abundance and fishing mortality under such strategies.

Appropriate for the species:

Whether a reference point is appropriate for a species depends on its life history characteristics, its productivity dynamics and its role in the ecosystem.

In respect to forage species: Most modern assessments use a stock-recruitment curve that is described by stationary parameters, including virgin biomass or B_0 and are not appropriate for species with dynamic productivity that shifts in response to environmental conditions. While it is possible to calculate reference points based on dynamic virgin biomass (acknowledging that the carrying capacity of the environment for these species is different based on favorable to unfavorable environmental conditions), to date, none exist in practice for any species. For certain taxa, like forage species that have an exceptionally important role in the ecosystem, reference points, in addition to being dynamic, should be based on ecosystem considerations (i.e. maintaining enough biomass to allow the species to fulfill its ecological role), rather than MSY or single-species considerations. For forage species (defined as in the Lenfest Forage Fish Task Force report, Box 1.1), reference points should be consistent with the precautionary principles recommendations of the Lenfest Forage Fish Task Force. Given these considerations, in most situations, Seafood Watch considers forage stock biomass and fishing mortality to be unknown.

Artificial production

The artificial propagation of fish that are released into the natural environment. Artificial production is commonly used for salmon and trout to increase the number of fish available to be caught or to recover depleted populations. Typically eggs collected from adult fish are incubated in a hatchery until the juveniles have emerged. The resulting juveniles are released into freshwater or marine waters after being held for some period of time in the hatchery (varies from weeks to a year or more). Sometimes referred to as “salmon ranching,” this is distinguished from “salmon farming” where fish are held captive throughout their entire lives. Artificial production can also include less traditional forms of artificial propagation such as artificial spawning channels, streamside incubation boxes, lake fertilization, etc.

Bycatch:

Refers to all fisheries-related injury or mortality other than in the retained catch. Examples include discards, endangered or threatened species catch, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is both valid scientific evidence of high post-release survival **and** no documented evidence of negative impacts at the population level.

Critically endangered:

An IUCN category for listing endangered species. A taxon is considered "critically endangered" (CE) when it faces an extremely high risk of extinction in the wild in the immediate future, as defined by any of the relevant IUCN criteria for "critically endangered" (FAO Glossary; IUCN).

Data-moderate:

Reliable estimates of Target Reference Point quantities are either unavailable or not useful due to life history, a weak stock-recruit relationship, high recruitment variability, etc. Reliable estimates of current stock size, life history variables and fishery parameters exist. Stock assessments include some characterization of uncertainty (Restrepo and Powers 1998; Restrepo et al. 1998).

Data-poor:

Refers to fisheries for which there are no estimates of MSY or relevant reference points, stock size, or certain life history traits. There may be minimal or no stock assessment data, and uncertainty measurements may be qualitative only (Restrepo and Powers 1998; Restrepo et al. 1998).

Data-rich:

Refers to fisheries with reliable estimates of MSY-related or relevant target quantities and current stock size. Stock assessments are sophisticated and account for uncertainty (Restrepo and Powers 1998; Restrepo et al. 1998).

Depleted:

A stock at a very low level of abundance compared to historical levels, with dramatically reduced spawning biomass and reproductive capacity. Such stocks require particularly energetic rebuilding strategies. Recovery times depend on present conditions, levels of protection and environmental conditions. May refer also to marine mammals listed as "depleted" under the Marine Mammal Protection Act (FAO Glossary). Classifications of "overfished" or "depleted" are based on assessments by the management agency and/or FAO, but analysts can use judgment to override the classification, especially where the prior assessment may be out of date (also includes IUCN listings of "near threatened", "special concern" and "vulnerable"). Inclusion in this classification based on designations such as "stock of concern" is determined on a case-by-case basis, as such terms are not used consistently among management agencies. Stocks should be classified as "depleted" if the stock is believed to be at a low level of abundance such that reproduction is impaired or is likely to be below an appropriate limit reference point. Marine mammals classified as "depleted" under the Marine Mammal Protection Act fall into this category, if not listed as endangered or threatened. Also includes stocks most likely (>50% chance) below the level where recruitment or productivity is impaired. *Note:* Official IUCN listings should be overridden by more recent and/or more specific classifications, where available (e.g., NMFS stock assessment showing stock is above target levels).

Ecological role:

The natural trophic role of a stock within the ecosystem under consideration in an assessment (MSC 2010).

Effective:

Management or mitigation strategies are defined as "effective" if a) the management goal is sufficient to maintain the structure and function of affected ecosystems in the long-term, **and** b) there is scientific evidence that they are meeting these goals.

Effective mitigation or gear modification:

A strategy that is "effective" as defined above, either in the fishery being assessed or as demonstrated in a very similar system (See Appendix 5 and Appendix 6 for a partial list of effective mitigations; this list will be continually developed).

Endangered/threatened:

Taxa in danger of extinction and whose survival is unlikely if causal factors continue operating. Included are taxa whose numbers have been drastically reduced to a critical level or whose habitats have been so drastically impaired that they are deemed to be in immediate danger of extinction (FAO Fisheries Glossary). This classification includes taxa listed as "endangered" or "critically endangered" by IUCN or "threatened", "endangered" or "critically endangered" by an international, national or state government body, as well as taxa listed under CITES Appendix I. This classification does not include species listed by the IUCN as "vulnerable" or "near threatened". Marine mammals listed as "strategic" under the Marine Mammal Protection Act are also considered as endangered/threatened if they are listed because "based on the best available scientific information, [the stock] is declining and is likely to be listed as a threatened species under the ESA within the foreseeable future." However, marine mammal stocks listed as "strategic" because "the level of direct human-caused mortality exceeds the potential biological removal level," or because they are listed as "depleted" under the Marine Mammal Protection Act, are instead classified as species of concern. If there is more recent information to suggest that the status of the population under consideration is healthier than suggested by IUCN, for example from a data-limited stock assessment, and the IUCN assessment is greater than 10 years old the IUCN status can be overridden. If local wildlife protection listings, for example the U.S. Endangered Species Act or Canadian Species at Risk Act, are being used to override the IUCN listing, the local status must be based on biological evidence rather than a political decision not to list the species.

Exceptional importance to the ecosystem:

A species that plays a key role in the ecosystem that may be disrupted by typical levels of harvesting, including: keystone species (those that have been shown or are expected to have community-level effects disproportionate to their biomass), foundation species (habitat-forming species, e.g., oyster beds), basal prey species (including krill and small pelagic forage species such as anchovies and sardines), and top predators, where the removal of a small number of the species could have serious ecosystem effects. Species that do not fall into any of these categories but that have been demonstrated to have an important ecological role impeded by harvest (e.g., studies demonstrating trophic cascades or ecosystem phase shifts due to harvesting) shall also be considered species of exceptional importance to the ecosystem (Paine 1995; Foley et al. 2010).

FishBase vulnerability:

Cheung et al. (2005) used fuzzy logic theory to develop an index of the intrinsic vulnerability of marine fishes. Using certain life history parameters as input variables—maximum length, age at first maturity, longevity, von Bertalanffy growth parameter K, natural mortality rate, fecundity, strength of spatial behavior and geographic range—together with heuristic rules defined for the fuzzy logic functions, fish species were assigned to either a very high, high, moderate or low level of intrinsic vulnerability. In this framework, intrinsic vulnerability is also expressed with a numerical value from 1 to 100 with 100 being most vulnerable. This index of intrinsic vulnerability was then applied to over 1300 marine fish species to assess intrinsic vulnerability in the global fish catch (Cheung et al. 2007). FishBase, the online global database of fish, includes this numerical "vulnerability score" on the profiles of fish species for which this analysis has been conducted (Froese and Pauly 2010).

Fluctuating biomass:

- If a stock is trending upwards (based on the most recent assessment) and has just recently exceeded the target reference point (TRP) or escapement/spawning benchmark, it can be ranked as "**low concern**." If a stock is not trending but is truly fluctuating around the RP (exceeding in some years and falling short in others, but with no clear trend), it can be ranked as **"low concern."**
- If a stock is below the LRP, it is considered **a "high concern."**

Fluctuating fishing mortality:

- If F is trending downwards or was previously above F_{MSY} (or a suitable proxy) but has recently gone below F_{MSY} (in the most recent assessment), fishing mortality should be ranked as "**low concern."**
- If F is fluctuating around F_{MSY}, or if F has been consistently below F_{MSY} and has just recently (in the latest assessment) risen above F_{MSY} for just this one year (potentially due to management error or a new stock assessment and the consequent adjustment in reference points or estimates), fishing mortality should be ranked as **"moderate concern**."
- If F is trending upwards and has just risen above F_{MSY} (or a suitable proxy), fishing mortality should be ranked as "**high concern"** unless there is a substantial plan to bring F back down. Such a plan would need to differ substantially from the existing harvest control rules (HCR), as those evidently did not keep F at a sufficiently low level.

Highly appropriate management strategy:

Management that is appropriate for the stock and harvest control rules takes into account major features of the species' biology and the nature of the fishery. Such a management strategy incorporates the precautionary approach while also taking uncertainty into account and evaluating stock status relative to reference points, as these measures have been shown to be robust (modified from MSC 2010). As an example, if management is based on Total Allowable Catch, these limits are set below MSY and/or scientifically advised levels, accounting for uncertainty, and lowered if $B<B_{MSY}$. However, alternatives to TAC-based management, such as area-based (closures), 3S (size, sex and/or season limitations) or other appropriate methods may also apply (Appendix 3).

Historic high:

Refers to near-virgin biomass, or highest recorded biomass, if biomass estimates predate the start of intensive fishing. If a fishery has been historically depleted and then rebuilt, the rebuilt biomass is not considered a "historic high" even though it may be higher than historical levels.

Inherent vulnerability:

A stock's vulnerability to overfishing based on inherent life history attributes that affect the stock's productivity and may impede its ability to recover from fishing impacts. Marine finfish are considered highly vulnerable when their FishBase vulnerability score falls into the categories high "vulnerability," "high to very high vulnerability," or "very high vulnerability" (scores of 55 or above) based on the FishBase vulnerability score (derived from the formula in Cheung et al. 2005). All sea turtles, marine mammals, and seabirds are considered "highly vulnerable." Marine invertebrates' vulnerability is based on the average of several attributes of inherent productivity.

One of the first key papers on this subject (Musick 1999) summarizes the results of an American Fisheries Society (AFS) workshop on the topic and offers proposed low, medium and high "productivity index parameters" (for marine fish species) based on available life history information: the intrinsic rate of increase r, the von Bertalanffy growth function k, fecundity, age at maturity and maximum age. Notably, although a species' intrinsic rate of increase is identified as the most useful indicator, it is also difficult to estimate reliably and is often unavailable (Cheung et al. 2005). To enable more timely and less data-intensive and costly identification of vulnerable fish species, Cheung et al. (2005) used fuzzy logic theory to develop an index of the intrinsic vulnerability of marine fishes based on life history parameters: maximum length, age at first maturity, longevity, von Bertalanffy growth parameter K, natural mortality rate, fecundity, strength of spatial behavior and geographic range (input variables). The index also uses heuristic rules defined for the fuzzy logic functions to assign fish species to one the following groups: very high, high, moderate or low level of intrinsic vulnerability.

In this framework, intrinsic vulnerability is also expressed by a numerical value between 1 and 100 with 100 being most vulnerable. This index of intrinsic vulnerability was then applied to over 1300 marine fish species to assess intrinsic vulnerability in the global fish catch (Cheung et al. 2007). FishBase, the online global database of fish, uses the numerical value from this index as a "vulnerability score" on the profiles of fish species for which it has been evaluated (Froese and Pauly 2010).

Large portion of the stock is protected:

At least 50% of the spawning stock is protected, for example through size/sex/season regulations or the inclusion of greater than 50% of the species' habitat in marine reserves. Future guidance will improve the integration of marine reserve science into the criteria, based on ongoing research.

Likelihood:

Highly likely: 70% chance or greater, when quantitative data are available; may also be determined by analogy from similar systems when supported by limited data from the fishery and no scientific controversy exists (modified from MSC 2010 and based on guidance from MSC FAM Principle 2). Examples of high likelihood for fishing mortality:

- All estimates of fishing mortality are within 70% or greater (e.g., 80% or 95%) confidence intervals, or all estimates of F from all scientifically feasible models and assumptions, are below F_{MSY} or equivalent.
- Estimate of F is at 75% of sustainable levels of F (such as F_{MSY}) or less, or estimates of catch are <75% MSY if the fishery is at or above B_{MSY} (if F is fluctuating, see "fluctuating F" for more guidance).
- Exploitation is very low compared to natural mortality, mortality from other sources or population size

Likely: 60% chance or greater, when quantitative data are available; may also be determined according to expert judgment and/or plausible argument (modified from MSC 2010 and based on guidance from MSC FAM Principle 2).

Probable: Greater than 50% chance; can be based on quantitative assessment, plausible evidence or expert judgment. Examples of "probable" occurrence for fishing mortality:

There may be some uncertainty or disagreement among various models; fishing mortality may be above 75% of a sustainable level and/or catch may be above 75% of a sustainable catch level (e.g., MSY) for stocks at B_{MSY}.

Main species:

A species is included in the assessment as a main species if:

- The catch of the species in the fishery under assessment composes >5% of that fishery's catch, *or*
- The species is >1% of that fishery's catch *and* the fishery causes >5% of the species' total mortality across all fisheries, *or*
- The species is <1% of that fishery's catch *and* the fishery causes >20% of species' total mortality across all fisheries, *or*
- The species is overfished, depleted, a stock of concern, endangered, threatened, IUCN Near Threatened, US MMPA strategic species, and/or subject to overfishing *and* the fishery causes >1% of species' total mortality across all fisheries.
- If there are no other "main species" (based on the above guidance) besides the one assessed under criterion 1, but the total catch of other discarded and retained species is >5% (i.e. catch of criterion 1 species is <95% of total), assess the top 3 species by volume of catch (if there are only 1-2 other species caught, assess those species).

Major SMUs:

In many salmon fisheries a number of different stocks of the same target species will be caught together, which often poses difficult challenges for fishery managers as some of these stocks may be abundant and capable of support relatively high exploitation rates while others may be depleted or endangered. To ensure that Seafood Watch assessments reflect the impact of salmon fisheries on the target stocks, only stocks which make up 5% or more of the landings (averaged over the most recent five years), will be considered major SMUs and assessed under Criterion 1. All other stocks are considered minor as described below.

Managed appropriately:

Management uses best available science to implement policies that minimize the risk of overfishing or damaging the ecosystem, taking into account species vulnerability along with scientific and management uncertainty.

Minor SMUs:

In many salmon fisheries a number of different stocks of the same target species will be caught together, which often poses difficult challenges for fishery managers as some of these stocks may be abundant and capable of supporting relatively high exploitation rates while others may be depleted or endangered. Seafood Watch recognizes that even the most effective management systems will not be able to exclude the capture of depleted stocks completely but expects their contribution to landings to be minimized. Therefore any stocks which constitute less than 5% of the landings (averaged over the most recent five years), are considered minor SMUs caught incidentally alongside target SMUs. Minor SMUs should be assessed under Criterion 2.

Negative genetic or ecological effects:

Artificial production can reduce the genetic fitness of the wild stock (Factor 1.2) through genetic introgression and reduced genetic diversity (Kostow 2008; Araki and Schmid 2010; Zhivotovsky et al. 2011). The process of capturing and breeding adult fish for brood stock will, intentionally or unintentionally, introduce artificial selection for genetic and phenotypic traits different than would occur in the wild (e.g., larger or earlier migrating fish). When these fish stray away from the hatchery location and spawn naturally with the wild stock, the offspring can have reduced genetic fitness. Artificial production may also have negative ecological effects (Factor 5.2.4), including disease transmission, predation, and competition between artificially produced and wild fish and other species in freshwater (Naish et al. 2007, Kostow 2008) and marine environments (Kaeriyama et al. 2009, Ruggerone et al. 2010). In addition, artificial production facilities can have negative ecological effects on the environment by blocking natural fish migration, or discharge of improperly treated effluent water and chemicals. Unfortunately, these impacts are generally poorly understood for most fisheries, but where impacts are likely, ecosystem-based management should include measures specifically designed, and in the best cases, proven to reduce these impacts. Further guidance on evaluating ecological effects due to artificial production can be found in Appendix 8.

Negligible:

Mortality is insignificant or inconsequential relative to a sustainable level of total fishing mortality (e.g., MSY or PBR); less than or equal to 5% of a sustainable level of fishing mortality.

No management:

A fishery with no rules or standards for regulating fishing catch, effort or methods. Management does not need to be enforced through government regulation or official management agencies but may also include voluntary action taken by the fishery, as long as there is general compliance.

Overfished:

A stock is considered “overfished” when exploited past an explicit limit where abundance is considered too low to ensure safe reproduction. In many fisheries, the term “overfished” is used when biomass has been estimated below a biological reference point used to signify an “overfished condition”. The stock may remain overfished (i.e., with a biomass well below the agreed limit) for some time even though fishing mortality may have been reduced or suppressed (FAO Glossary). Classification as “overfished“ or “depleted“ (including IUCN listing as “Near Threatened,” “Special Concern” and “Vulnerable”) is based on evaluation by the management agency and/or FAO, but an analyst can use judgment to override this classification, especially where the classification may be out of date as long as there is scientific justification for doing so. Inclusion in the “overfished” category based on designations such as “stock of concern” are determined on a case-by-case basis, as such terms are not used consistently among management agencies. Stocks should be classified as “overfished” if the stock is believed to be at such a low level of abundance that reproduction is impaired or is likely to be below an appropriate limit reference point. Marine mammals classified as “depleted” under the Marine Mammal Protection Act also fall into this category if not listed as endangered or threatened. Stocks that are most likely (>50% chance) below the level where recruitment or productivity is impaired are also considered “overfished”. *Note:* Official IUCN listings should be overridden by more recent and/or more specific classifications where available (e.g., NMFS stock assessment showing that a stock is above target levels).

Overfishing:

A generic term used to refer to a level of fishing effort or fishing mortality such that a reduction of effort would, in the medium term, lead to an increase in the total catch; or, a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis. For long-lived species, overfishing (i.e., using excessive effort) starts well before the stock becomes overfished. Overfishing, as used in the Seafood Watch® criteria, can encompass biological or recruitment overfishing (but not necessarily economic or growth overfishing).

- *Biological overfishing*: Catching such a high proportion of one or all age classes in a fishery as to reduce yields and drive stock biomass and spawning potential below safe levels. In a surplus production model, biological overfishing occurs when fishing levels are higher than those required for extracting the Maximum Sustainable Yield ($_{MSY}$) of a resource and recruitment starts to decrease.
- *Recruitment overfishing*: When the rate of fishing is (or has been) high enough to significantly reduce the annual recruitment to the exploitable stock. This situation is characterized by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch and generally very low recruitment year after year. If prolonged, recruitment overfishing can lead to stock collapse, particularly under unfavorable environmental conditions.
- *Growth overfishing:* Occurs when too many small fish are being harvested too early through excessive fishing effort and poor selectivity (e.g., excessively small mesh sizes), and the fish are not given enough time to grow to the size at which maximum yield-per-recruit would be obtained from the stock. Reduction of fishing mortality among juveniles, or their outright protection, would lead to an increase in yield from the fishery. Growth overfishing occurs when the fishing mortality rate is above F_{max} (in a yield-per-recruit model). This means that individual fish are caught before they have a chance to reach their maximum growth potential. Growth overfishing, by itself, does not affect the ability of a fish population to replace itself.
- *Economic overfishing*: Occurs when a fishery is generating no economic rent, primarily because an excessive level of fishing effort is applied in the fishery. This condition does not always imply biological overfishing.

(FAO Glossary; NOAA 1997)

pHOS:

The **p**roportion of **h**atchery-**o**rigin (artificially produced) spawners contributing to the total natural **s**pawning population or SMU (including both hatchery-origin and natural-origin spawners).

pNOB:

The **p**roportion of **n**atural-**o**rigin (i.e., wild or not artificially produced) fish contributing to the total hatchery **b**roodstock for a particular program, population or SMU.**Population:**

Within this standard, population refers to a group of naturally interbreeding salmon independent from other such groups. Indicators of a distinct salmon population may include: genetics, demographics, geographic isolation, and adaption to the local habitat. Populations may be defined by NOAA fisheries to aid in the establishment of the U.S. Endangered Species Act (ESA) and within salmon recovery plans. NOAA Fisheries considers hatchery-origin salmon to be part of a population in some cases (through interbreeding) but does not consider a population dependent on naturally spawning hatchery fish to be viable.

Precautionary approach:

The precautionary approach involves the application of prudent foresight. Taking account of the uncertainties in fisheries systems and considering the need to take action with incomplete knowledge, the precautionary approach requires, inter alia: (i) consideration of the needs of future generations and avoidance of changes that are not potentially reversible; (ii) prior identification of undesirable outcomes and measures to avoid or correct them promptly; (iii) initiation of any necessary corrective measures without delay and on a timescale appropriate for the species' biology; (iv) conservation of the productive capacity of the resource where the likely impact of resource use is uncertain; (v) maintenance of harvesting and processing capacities commensurate with estimated sustainable levels of the resource and containment of these capacities when resource productivity is highly uncertain; (vi) adherence to authorized management and periodic review practices for all fishing activities; (viii) establishment of legal and institutional frameworks for fishery management within which plans are implemented to address the above points for each fishery, and (ix) appropriate placement of the burden of proof by adhering to the requirements above (modified from FAO 1996).

Productivity is maintained/not impaired:

Fishing activity does not impact the stock, either through reduced abundance, changes in size, sex or age distribution, or reduction of reproductive capacity at age, to a degree that would diminish the growth and/or reproduction of the population over the long-term (multiple generations).

Productivity–susceptibility analysis (PSA):

Productivity-susceptibility analysis was originally developed to assess the sustainability of bycatch levels in Australia's Northern Prawn fishery (Patrick et al. 2009), and has since been widely applied to assess vulnerability to fishing mortality for as number of fisheries worldwide. Productivity-susceptibility analysis is used by NOAA and the Australian Commonwealth Scientific Industrial Research Organization (CSIRO) to inform fisheries management. It also constitutes the basis of the risk-based framework used to evaluate data-poor fisheries under the Marine Stewardship Council Fishery Assessment Methodology (MSC FAM). The PSA approach allows the risk of overfishing to be assessed for any species based on predetermined attributes, even in the most data-poor situations.

The exact sets of productivity and susceptibility attributes vary between PSA methodologies, and different weighting of attributes can be employed based on relative contextual importance. Additionally, scoring thresholds can vary depending on the context in which PSA is employed. In the US methodology, productivity is defined as the capacity for a stock to recover once depleted, which is largely a function of the life history characteristics of the species. Generally, productivity attributes are similar to the life history parameters used for the above index of intrinsic vulnerability.

While PSA analysis is a widely accepted approach for evaluating risk of overexploitation of a fished species, for the purposes of Seafood Watch assessments it is useful to separate the productivity attributes—which are intrinsic to a species and neither dependent on nor influenced by fishery practices—from the susceptibility attributes. Fisheries may influence the susceptibility of impacted stocks through the choice of gear, bait species, hook design, mesh size, area or seasonal closures, and other management measures. In addition, where detailed information on fishing mortality (e.g., estimates of F or harvest rates) is available, these data provide a more complete picture of the fishery impact that the susceptibility attributes are designed to predict. Therefore, under the revised Seafood

Watch® criteria, the "inherent vulnerability" score will be derived from the FishBase vulnerability score, which address only those characteristics intrinsic to the species and equivalent to the productivity attributes considered under PSA. Susceptibility attributes will be separately considered as part of the evaluation of fishing mortality when more specific data are not available.

Because the FishBase vulnerability index has not been evaluated for application to marine invertebrates (Cheung, pers comm., 2011), we propose the use of "productivity" attributes from the PSA methodology used by the MSC, with adjustments to account for particular aspects of marine invertebrate life history (see Criterion Factors 1.1 and 2.1 for guidance).

Changes to PSA resilience attributes made to increase applicability to invertebrates include:

- Removal of "average maximum size" and "average size at maturity" attributes, as body size has been demonstrated not to correlate with extinction risk for marine invertebrates (McKinney 1997, Finnegan et al. 2009).
- Incorporation of fecundity in the average only if fecundity is low, as strong evidence suggests that high fecundity does not necessarily correlate with low vulnerability; however, low fecundity does seem to correspond with high vulnerability (Dulvy et al. 2003, Cheung et al. 2005).
- Removal of the "trophic level" attribute. Anecdotally, trophic level does not appear to be a strong predictor of extinction risk for marine invertebrates. Some of the most vulnerable marine invertebrates are at the lowest trophic level (e.g., abalone). Additionally, in a review of Canadian fishes, trophic level was not found to be a strong predictor of extinction risk in marine fishes (O'Malley 2010; Pinsky et al. 2011).
- Incorporation of density dependence, particularly the existence of depensatory dynamics, or Allee effects, for small populations. Allee effects may have a profound effect on the resilience of marine invertebrates to fishing mortality (Hobday et al. 2001, Caddy 2004).

Reasonable timeframe (for rebuilding):

Dependent on the species' biology and degree of depletion, but generally within 10 years, except in cases where the stock could not rebuild within 10 years even in the absence of fishing. In such cases, a reasonable timeframe is within the number of years it would take the stock to rebuild without fishing, plus one generation, as described in Restrepo et al. (1998).

Recent stock assessment:

As a rule of thumb, stock assessments or updates based on data collected within the last five years are considered to be recent. If the data used within an assessment, are >5 years old, but <10 years old, and show that biomass is above target reference points it should be scored as a "low concern" in most cases, but with consideration of trends and time series; *e.g.*, if the population has been stable and was well above the TRP in the last assessment, and the species is not one that fluctuates greatly in abundance, and the fishery hasn't changed dramatically in recent years, a "very low concern" may be justified. If the stock assessment is very out of date—as a rule of thumb, data are >10 years old—the stock status should be considered unknown and rated accordingly. It may be considered unknown even when the assessment is less than 10 years old in circumstances where the stock was previously very close to reference points or is very dynamic. If the most recent stock assessment was not accepted by the relevant scientific body for any reason, the stock should be considered unknown. If older data are used within an assessment which is ultimately approved by a relevant scientific body (knowing that the data are old), the results can be considered appropriate and scored a “low concern”; this outcome is expected to be rare.

Recruitment is impaired:

Fishing activity impacts the stock—either through reduced abundance, changes in size, sex or age distribution, or reduction of reproductive capacity at age—to a degree that will diminish the growth and/or reproduction of the population over the long-term (multiple generations); or, the stock is below an appropriate limit reference point, if one is defined.

Recent years:

When determining whether a stock is trending upward or downward in recent years, the term “recent years” should be considered to be the most recent 5 years in the time-series being assessed.

Regularly monitored:

Fishery-independent surveys of stocks, or other reliable assessments of abundance, are conducted at least every three years.

Relevant legal requirements:

These include state, national and international laws which pertain to the fishery.

Reliable data:

Data produced or verified by an independent third party. Reliable data may include government reports, peer-reviewed science, audit reports, etc. Data are not considered reliable if significant scientific controversy exists over the data, or if data are old or otherwise unlikely to represent current conditions (e.g., survey data is several years old and fishing mortality has increased since the last survey).

Representative populations:

A group of populations that reflect the genetic diversity and productive capacity of the entire stock management unit. The intent is that the populations affected by artificial production should not represent a disproportionate share of the total productive capacity or genetic and life history diversity within the stock management unit.

Segregated program:

A strategy where hatchery populations are maintained (intentionally or in practice) as isolated reproductive groups (little or no influx of natural-origin fish in hatchery broodstock) and there is explicit management intent/desire for hatchery fish not to stray into and spawn with wild populations, or to a very limited extent.

Species of concern:

Species about which management has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species as endangered. In the U.S., this may include species for which NMFS has determined, following a biological status review, that listing under the ESA is "not warranted," pursuant to ESA section 4(b)(3)(B)(i), but for which significant concerns or uncertainties remain regarding their status and/or threats. Species can qualify as both "species of concern" and "candidate species" (http://www.nmfs.noaa.gov/pr/glossary.htm#s). In addition, marine mammal stocks listed as “strategic” because “the level of direct human-caused mortality exceeds the potential biological removal level” are classified as species of concern. The terms “species of concern” or “stock of concern” are used similarly by other federal and state management bodies.

Stakeholder input:

A stakeholder is an individual, group or organization that has an interest in, or could be affected by, the management of a fishery (modified from MSC 2010). Stakeholder input may include: involvement in all key aspects of fisheries management from stock assessment and setting research priorities to enforcement and decision-making. In addition, stakeholders may take ownership of decisions and greater responsibility for the wellbeing of individual fisheries (Smith et al 1999). Effective stakeholder engagement requires that the management system has a consultation processes open to interested and affected parties and that roles and responsibilities of the stakeholders are clear and understood by all relevant parties (modified from MSC 2010).

Stock:

A self-sustaining population that is not strongly linked to other populations through interbreeding, immigration or emigration. A single fishery may capture multiple stocks of one or multiple species. Stocks can be targeted or non-targeted, retained or discarded, or some combination thereof (e.g., juveniles are discarded and adults are retained).

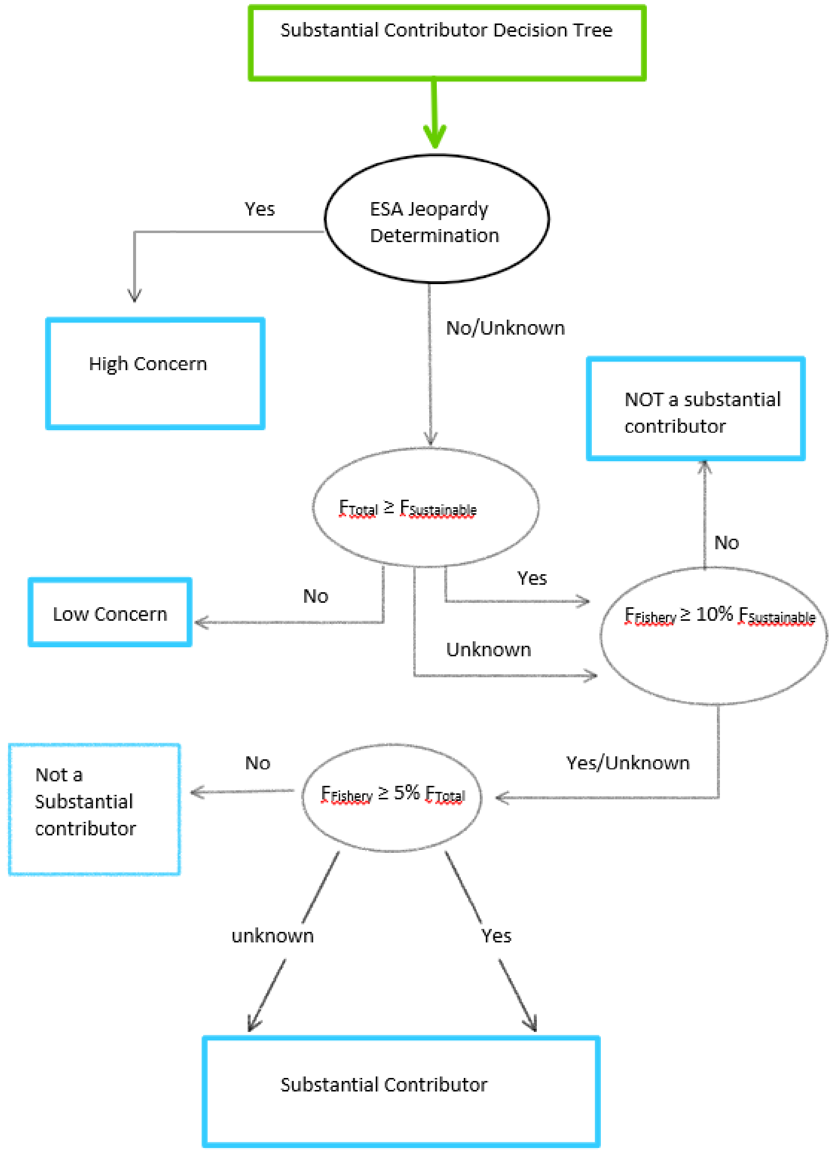
Ideally, the stock management unit should correspond to the biological unit. However, often the fisheries management unit of "stock" may not be the same as the biological unit. If multiple biological stocks are managed as one, and there is insufficient information to assess the stock status of each biological stock, the management unit is assessed. The effectiveness of management can be assessed at the finest scale for which meaningful and verifiable differences in management practice exist.

Stock Management Unit (SMU):

A group of one or more populations for which fishery management objectives have been established—typically for salmon a spawning escapement goal—and for which fisheries will be regulated to achieve. The Stock Management Unit is a broad management concept, such that not every population with a defined goal need be an individual SMU but can be part of a collection of such populations within an SMU (adapted from MSC 2014).

Substantial contributor:

A fishery is a substantial contributor to impacts affecting a population, ecosystem or habitat if the fishery is a main contributor, or one of multiple contributors of a similar magnitude, to cumulative fishing mortality. Examples of a fishery that is **not** a substantial contributor include: (a) catch of the species is a rare or minor component of the catch in this fishery **and** the fishery is a small contributor to cumulative mortality, relative to other fisheries. However, if there has been a jeopardy determination for that stock in the fishery being assessed it should be considered a substantial contributor regardless of this definition. This applies to species assessed under Criterion 2 only. In exceptional cases, fishing mortality on a stock of concern may have been reduced to almost zero such that any fisheries interacting with a stock would be considered a substantial contributor to total fishing mortality; however, in these cases it is important to consider other sources of mortality, including natural mortality, which may be more significant. Where total fishing mortality is very low and there is evidence that other sources of mortality are impacting a stock, fishing mortality can be considered a non-substantial contributor. In order to assist in determining whether a fishery is a substantial contributor, please consider the decision tree below which aims to determine the level of impact of a fishery relative to a sustainable level, or other fishing impacts.



Substantial proportion of habitat:

Refers to a condition when at least 20% of each representative habitat (where representative habitats can be delineated by substrate, bathymetry, and/or community assemblages), within both the range of the targeted stock(s) and the regulatory boundaries of the fishery under consideration (i.e., within the national EEZ for the fishery under consideration), is completely protected from fishing with gear types that impact the habitat in that fishery.

Susceptibility (low/moderate/high)

A stock's capacity to be impacted by the fishery under consideration, depending on factors such as the stock's likelihood to be captured by the fishing gear. The susceptibility score is based on tables from MSC's Productivity-Susceptibility Analysis framework. Examples of low susceptibility include: low overlap between the geographic or depth range of species and the location of the fishery; the species' preferred habitat is not targeted by fishery; the species is smaller than the net mesh size as an adult, is not attracted to the bait used, or is otherwise not selected by fishing gear; or strong spatial protection or other measures in place specifically to avoid catch of the species.

Sustainable level (of fishing mortality):

A level of fishing mortality that will not reduce stock below the point where recruitment is impaired, i.e., above F reference points, where defined. The F limit reference points should be around either F_{MSY} or F35–40% for moderately productive stocks; low productivity stocks like rockfish and sharks require F in the range of F50–60% or lower. Higher F values require a strong scientific rationale. For example, the F reference points are limit reference points, so buffers should be used to ensure that fishing mortality does not exceed these levels. Where F is unknown but MSY is estimated, fishing mortality at least 25% below MSY is considered a sustainable level (for fisheries that are at or above B_{MSY}).

Transient Stock:

An SMU which is caught as part of a fishery but is not native to the region in which it is caught. Typically transient stocks are the same species as the target species and cannot be visually distinguished from the target stocks. Transient stocks should be considered target stocks and assessed under criterion 1 when they are the same species as the target species. They can be considered bycatch and assessed under criterion 2 if they are a different species than the target species.

Uncertainty:

Most data available to fisheries scientists contains uncertainty. Typically, we are dealing with estimates of catch size, population biomass and levels of natural and fishing mortality. As a result, stock assessments based on these data will also include uncertainty, which needs to be considered when interpreting said results for the purpose of a Seafood Watch assessment. In some cases, the uncertainty has been quantified, for example as a standard deviation or standard error of a biomass estimate. In such cases, these values can be used to determine whether the estimate is above or below a reference point. For example, where an estimate of biomass is greater than the target reference point we would expect factor 1.1 to be scored a "very low concern," however if uncertainty is such that the lower limit of the standard deviation falls below the target reference point, a "low concern" is a more appropriate score, in order to account for the uncertainty in the stock assessment result.

Up-to-date data/stock assessment:

Complete stock assessments are not required every 1–3 years, but stocks should be regularly monitored at least every 1–3 years, and stock assessments should be based on abundance and fishing mortality data not more than three years old. Data may be collected by industry, but analysis should be independent.

Very limited area:

Fishing (with damaging gear, when assessing Criterion D) is limited to no more than 50% of each representative habitat (where representative habitats can be delineated by substrate, bathymetry, and/or community assemblages) within both the range of the targeted stock(s) and the regulatory boundaries of the fishery under consideration (e.g., the national EEZ for the fishery under consideration).

Very low levels of exploitation (e.g., experimental fishery):

Fishery is under-exploited or is being conducted experimentally to collect data or gauge viability, such that exploitation rates are far below sustainable yields (e.g., 20% or less of sustainable take). Alternatively, when no other information is available, exploitation levels may be considered very low if a fishery falls into the "low" category for all "susceptibility" questions under Productivity-Susceptibility Analysis.

Wild (salmon):

Any fish not supplied by artificial production; synonymous with "natural-origin" for the purposes of this standard.

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Appendices

Appendix 1 – Further guidance on interpreting the health of stocks and fishing mortality

The tremendous variability among fisheries makes it impossible to define specific appropriate reference points that would be applicable to all assessed fisheries. Instead, criteria are based on the commonly accepted management goal that target biomass should be at or above the point where yield is maximized, and management should ensure a high probability that biomass is at or above a limit reference point (where recruitment or productivity of the stock would be impaired). Three common types of reference points are *MSY-based, SPR-based,* and *ICES reference points.* However, other reference points may be used in some fisheries, and should be evaluated in accordance with the management goal articulated above.

Evaluating Abundance

MSY-based reference points
While the concept of MSY is far from perfect, MSY-based biomass and fishing mortality reference points are commonly used in some of the most well managed fisheries around the world. When applied appropriately, these reference points are an important tool for maintaining stock productivity in the long term. However, without properly accounting for scientific and management uncertainty, maintaining a stock at B_{MSY} (the biomass corresponding to MSY) and harvesting at MSY runs a high risk of unknowingly either overshooting MSY or allowing biomass to drop below B_{MSY} without reducing harvest rates and thus inadvertently overharvesting (Roughgarden and Smith 1996; Froese et al. 2010). The risk of impacts from inadvertent overharvesting increases with increased uncertainty and with increased inherent vulnerability of the targeted stock. To account for these interactions, the guidance provided for assessing stock health and fishing mortality is based on MSY reference points but requires high scientific confidence that biomass is above target levels and that fishing mortality is below MSY.

Proxies for B_{MSY} are acceptable if shown to be conservative relative to B_{MSY} for that stock, or if they fit within the guidelines for appropriate target level*. Where B_{MSY} or other appropriate reference points are not known or are not applicable, the stock/population health criteria can be interpreted using relevant indicators that are appropriate as targets and safe limits for abundance of the species (*e.g.*, escapement relative to escapement goals can be evaluated in lieu of biomass relative to limit reference points).

ICES reference points
The current objective of ICES advice is to achieve MSY through Ecosystem Based Fisheries Management (ICES 2018).

Traditionally, the ICES reference points F_{PA}, F_{LIM}, B_{PA}, and B_{LIM} utilized were not equivalent to MSY-based reference points. In fact, comparisons demonstrated that F_{PA} is typically above F_{MSY} and B_{PA} is typically below B_{MSY}, such that MSY-based reference points are generally more conservative (ICES 2010). In many cases, B_{PA} is well below B_{MSY} and even below 1/2 B_{MSY} (Kell et al. 2005). Therefore, guidance for evaluating stock health using B_{PA} and fishing mortality using F_{PA} is conservative, accounting for the difference between these reference points and MSY-based reference points. ICES plans to has transitioned to an MSY-based approach (ICES 2018) Not all stock assessments may have been updated to this new approach however; therefore if $B>B_{PA}$ or $F<F_{PA}$, the stock should score as a moderate concern, unless a good reason exists to justify a "low concern" score for abundance (*i.e.,* either the reference points have been shown to be conservative **or** the biomass is well above reference points).

Proxies

For many fisheries, F_{MSY} and B_{MSY} are unknown, and proxies are often used. Most commonly, biomass proxies are based on the percent of unfished or virgin biomass (B_0). Fishing mortality proxies are often based on spawning potential ratio (SPR).

Commonly used and acceptable biomass reference points are typically 35–40% of B_0 for most stocks (Clark 1991; NZ Ministry of Fisheries 2008). This target may vary according to stock productivity; however, justifications for lower target levels are often based on assumptions about "steepness[13]" that may be highly uncertain or poorly understood. It is now recognized that stock targets lower than approximately 30-40% of B_0 are increasingly difficult to justify (NZ Ministry of Fisheries 2008). For these targets to be considered appropriate reference points, solid scientific justification is required. In addition, stocks reduced to this target level or below (equivalent to removing more than 60–70% of the stock's biomass) would be unlikely to achieve the ecosystem-based management goal of allowing a stock to fulfill its ecological role and should be scored accordingly under ecosystem-based management.

Alternatively, when unfished biomass cannot be estimated, appropriate biomass reference points may be based on the equilibrium biomass achieved using appropriate fishing mortality reference points, as described below.

A large body of scientific literature addresses appropriate fishing mortality reference points based on spawner biomass per recruit (SPR). Ideally, these should be shown through scientific analysis to be at or above replacement %SPR (the threshold level of SPR necessary for replacement) for the species, based on its productivity and S-R relationship (Mace and Sissenwine 1993). However, for many species this analysis will not be available. In these cases, guidance is based on the conclusions of numerous analyses demonstrating that, in general, $F_{35\text{-}40\%}$ (the fishing mortality rate that reduces the SPR to 35–40% of unfished levels) is appropriate for species with moderate vulnerability, while a more conservative fishing mortality rate of about $F_{50\text{-}60\%}$ is needed for highly vulnerable species such as rockfish and sharks (Botsford and Parma 2005; Mace and Sissenwine 1993; Clark 2002; Myers et al. 1999; Goodman et al. 2002).

Data-limited reference points and other metrics

In the absence of stock assessments and MSY-based reference points, the stock health can be evaluated based on CPUE, trends in abundance and size structure, and/or simple, easy to calculate reference points such as fraction of lifetime egg production (FLEP) (equivalent to spawning potential ratio, SPR) and an array of other data-limited assessment approaches. Other data-limited or alternative assessment techniques that provide evidence that stocks are healthy (*i.e.,* productivity and reproduction are not impaired) may be used in place of or to supplement reference points. Examples of simple metrics which provide evidence that a stock's productivity may have shifted include the Froese length-based indicators (2004) and their modifications by Cope and Punt (2009). FISHE (EDF 2016: available in the FISHE

[13] Steepness is a key parameter of the Beverton-Holt spawner-recruit model that is defined as the proportion of unfished recruitment produced by 20% of the unfished spawning biomass. Steepness is difficult to estimate, and the calculation of reference points is often very sensitive to estimates of steepness.

Resources section at http://fishe.edf.org/) provides information on these and other data-limited metrics. Dowling *et al.* 2019 provides a compendium of many existing data-limited approaches (see Table 1) and describes their uses, assumptions, and limitations. Appendix 7 provides guidance to SFW analysts on how to evaluate data-limited metrics when scoring abundance. SFW holds data-limited fisheries to the same standard of likelihood as data-rich fisheries when stocks are above a level where recruitment would be impaired and fishing mortality is at or below a sustainable level of harvest.

- Examples of evidence that a stock is above the point where recruitment or productivity is impaired, i.e., an appropriate limit reference point, include:
    - the current lifetime egg production (LEP) or spawning per recruit (SPR) is above an appropriate SPR or Fraction of Lifetime Egg Production (FLEP)-related reference point;
    - spawning potential is well protected (*e.g.*, females are not subject to mortality, and it can be shown or inferred that fertilization is not reduced);
    - quantitative analyses conducted by fishery scientists under transparent guidelines indicate sufficient stock;
- Strong, quantitative scientific evidence from the fishery under consideration is required to consider a stock a “very low concern” for abundance. When limited data are available from the fishery, analogy with similar systems, qualitative expert judgments and/or plausible arguments may be used to consider the stock as “low concern”;
- Use of CPUE requires the absence of hyperstability, that CPUE is proportional to abundance (or adjusted), and that there have been no major changes in technology;
- The LEP can be estimated from length frequency data from both unfished (or marine reserve) and current populations and does not require catch-at-age data. Reference points based on FLEP should be considered limit reference points.

For “very low concern” for abundance, there must be no evidence that productivity has been reduced through fisheries-induced changes in size or age structure, size or age at maturity, sex distribution, etc. SPR-based and MSY-based reference points should account for these changes as they are based on productivity of the stock rather than simple abundance. If the metric considers abundance only, or if there is evidence that productivity has been reduced through shifts in age, size or sex distributions, the stock cannot be rated higher than “low concern.” Moreover, “very low concern,” for abundance stock assessments or updates should be no more than five years old; have been approved through an independent scientific peer review process; and include verified fishery dependent and fishery independent abundance data and accurate life history data. Biomass information must be estimated with low uncertainty. In cases where these qualifications may not apply, the analyst must adequately justify his/her reasoning.

Evaluating Fishing Mortality

Evaluation of fishing mortality should reflect the mortality caused by the fishery, but in the context of whether cumulative impacts on the species (including mortality from other fisheries) are sustainable. When determining whether a fishery is a substantial contributor, err on the side of caution. Unknown or missing data are grounds for classification as a substantial contributor.

Reference points

Generally, species should be managed with reference points that fit the definition of a sustainable level of fishing mortality and/or an appropriate SPR or Fraction of Lifetime Egg Production (FLEP)-related reference point. Species that are not commercially fished or managed but make up non-target catch in the fishery will generally not have reference points defined. In lieu of reference points, these stocks should be evaluated relative to a level of mortality scientifically shown not to lead to depletion of the stock. For species with high vulnerability, the reference point must be demonstrated to be appropriate for that species' biology. As a rule of thumb, $F_{40\%}$ is not precautionary enough for high vulnerability species; $F_{50\%}$ or lower is more appropriate when using SPR-based proxies.

ICES reference points

Because analysis has shown that the previously utilized ICES reference point F_{PA} is typically above F_{MSY}, ICES stocks using F_{PA} as a reference point must be rated more conservatively than stocks using F_{MSY}. If $F > F_{PA}$, rate the stock as "high concern". If $F < F_{PA}$, rate the stock as "moderate concern," unless there is additional evidence that F is below a sustainable level such as F_{MSY}. These reference points may appear in older assessments that have not yet been updated utilizing the MSY approach.

Data-limited stocks

When no formal reference points are available (*i.e.,* in data-limited fisheries), , fishing mortality could be considered a low concern if the fishery has a low likelihood of interacting with a non-target species due to low overlap between the species range and the fishery, or due to low gear selectivity for the species (resulting in low susceptibility; see below). Fishing mortality on target or non-target species may be considered a low concern if there is a very low level of exploitation.

Age of Assessment

If the stock assessment, or the data used within it, is greater than 10 years old then there is a high level of uncertainty associated with the result (with respect to how it reflects the current situation). In cases where $F<F_{MSY}$ (or appropriate reference point) and the data are greater than 10 years old, fishing mortality should be considered "unknown" or a moderate conservation concern. In all cases where $F>F_{MSY}$ (or appropriate reference point), regardless of the age of assessment, fishing mortality should be scored as a high conservation concern.

Appendix 2 – Matrix of bycatch impacts by gear type

The matrices in this appendix are used to determine the relative impact of a fishery on bycatch species of various taxa for fisheries where species and amounts of bycatch are not available or are incomplete. The matrices represent typical relative impacts of different fishing gear on various taxa based on the best available science. If there are data that indicate a specific fishery is operating differently from the standard operating procedures, the UBM can be overruled.

Scoring abundance of unknown bycatch species:

Sea turtles, sharks, marine mammals, seabirds, and fish and invertebrate bycatch species from taxa known to be of high inherent vulnerability – including sharks, skates, rays, sturgeon, rockfish, grouper, corals, abalone and conch – should be scored as highly vulnerable, and thus a High Concern under the abundance factor (2.1). Other fish and invertebrates should generally be scored as a Moderate Concern, unless data exist that would indicate an alternative rating. For more guidance, see also “Additional guidance for scoring unknown bycatch species in Criterion 1.1/2.1 (Abundance)”, below.

Scoring fishing mortality of unknown bycatch species:

Highly vulnerable marine megafauna (sea turtles, marine mammals, seabirds and sharks)

Updated tables for highly vulnerable taxa (sea turtles, marine mammals, seabirds, and sharks) now incorporate a regional component. We generated these values based on an extensive literature review (54 reports, peer-reviewed articles) to better reflect the array of bycatch issues that occur using the same gear types in different regions of the world, reflecting the regional susceptibility of the taxa to gear. Only the turtle matrix also incorporates reproductive values because the literature incorporates age-related information that was not available for the other taxa. We incorporated the effect of mitigation measures only to the extent that bycatch studies were of fisheries that used bycatch reduction techniques.

Gear categories for Unknown Bycatch Matrices

FAO Gear Category	FAO Methods	FAO Abbreviation	MBA
DREDGES	Dredges (nei)	**LN**	**Use this for all dredges**
GILLNETS AND ENTANGLING NETS	Set gillnets	**GNS**	
	Drift gillnets (driftnets)	GND	
	Encircling gillnets	GNC	**Use GND**
	Fixed gillnets (on stakes)	GNF	**Use GNS**
	Trammel nets	GTR	**Use GNS**
	Combined gillnets - trammel nets	GTN	**Use GNS**
	Gillnets and entangling nets (nei)	GEN	**If on bottom GNS, if not fixed, GND. Could include liftnets and reefnets**
HOOKS AND LINES	Handlines and hand-operated pole-and lines	**LHP**	
	Mechanized lines and pole-and-lines	**LHM**	
	Set longlines	**LLS**	**Bottom longlines, Buoy gear**
	Drifting longlines	**LLD**	**Pelagic longline, Trotline**
	Trolling lines	**LTL**	**Greenstick, Jig**
MISCELLANEOUS GEARS	Harpoons	**HAR**	
	Diving	**MDV**	
SURROUNDING NETS	Purse seines	**PS**	**Dolphin set (D), Floating Object/whaleshark (F), Unassociated (U)**
	Surrounding nets (nei)	**SUX**	**Lampara, non-tuna PS, Danish seine, suripera, ring nets**
TRAPS	Pots	**FPO**	**Crab rings**
TRAWLS	Bottom trawls (nei)	**TB**	**Small or large mesh bottom trawl, Magdalena - Artisanal bottom trawl, butterfly trawl**
	Midwater trawls (nei)	**TM**	

Unknown bycatch matrix – sea turtles

Sea Turtle Bycatch Susceptibility

Region	Longline		Gillnet		Trawl		Dredge	Purse Seine				Other		
	LLS	LLD	GNS	GND	TB	TM	LN	SUX	PSF	PSD	PSU	FPO	HAR/ MDV	LTL/ LHP/LHM
Caribbean/Gulf of Mexico	1	2	1	1	1	2	3	4	3	--	4	4	5	5
East Indian Ocean/Southeast Asia	1	1	1	1	1	2	3	3	3	--	4	5	5	5
E. Pacific/Eastern Tropical Pacific	1	1	1	1	1	1	3	4	3	5	4	5	5	5
Mediterranean	1	1	1	1	1	2	3	5	5	--	5	5	5	5
North Pacific	2	2	2	2	3	3	3	4	3	--	4	5	5	4
Northeast Atlantic	2	2	3	3	3	3	3	4	3	--	4	3	5	5
Northwest Atlantic	2	2	3	3	1	1	3	4	3	--	4	5	5	5
Oceania (West Central Pacific)	1	1	4	4	4	5	3	2.5	2.5	--	3	5	5	5
W. Africa/Southeast Atlantic	1	1	1	1	2	2	3	4	3	--	4	5	5	5
Southwest Atlantic	1	1	1	1	1	1	3	4	3	--	4	5	5	5
Southwest Pacific (Australia/New Zealand)	3	3	1	1	1	2	3	4	3	--	4	5	5	5
West Indian Ocean and Red Sea	1	1	1	1	2	1	3	4	3	--	4	5	5	5

***For known, unassessed spp., ≥3.5 = low concern**

Unknown Bycatch Matrix – marine mammals

Marine Mammal Bycatch Susceptibility

Region	Longline		Gillnet		Trawl		Dredge	Purse Seine				Other		
	LLS	LLD	GNS	GND	TB	TM	LN	SUX	PSF	PSD	PSU	FPO	HAR/ MDV	LTL/ LHP/LHM
Caribbean/Gulf of Mexico	3	3	1	1	3	3	5	3.5	4	--	4	3	5	5
Southeast Asia (East Indian)	3	2	1	1	1	2	5	3.5	3	--	4	2	4	5
Eastern Tropical Pacific/Eastern Pacific	2	1	1	1	2	1	5	3	3	2	4	2	3	5
Mediterranean	2	2	1	1	1	1	5	3.5	4	--	3	2.5	4	5
Northeast Pacific	2	2	1	1	2	2	5	3	4	--	4	1	5	5
Northeast Atlantic	3	3	1	1	2	2	5	3.5	4	--	4	1	5	5
Northwest Atlantic	3	2	1	1	3	3	5	3.5	4	--	4	1	5	5
Northwest Pacific	1	2	1	1	1	2	5	3.5	4	--	4	1	5	5
Oceania (Western Central Pacific)	4	3	1	1	4	4	5	4	3	--	4	--	5	5
Southern Ocean	4	4	--	--	4	4	5	5	5	--	5	--	5	5
West Africa/Southeast Atlantic	3	3	1	1	3	1	5	1	2	--	2	1	5	5
Southwest Atlantic	3	3	1	1	2	2	5	3.5	4	--	4	4	5	--
Southwest Pacific (Australia/New Zealand)	3	1	1	1	1	3	5	3	4	--	3	2	5	5
West Indian Ocean and Red Sea	3	3	1	1	3	2	5	3.5	4	--	4	3	5	5

***For known, unassessed spp., ≥3.5 = low concern**

Unknown Bycatch Matrix - seabirds

Seabird Bycatch Susceptibility

Region	Longline		Gillnet		Trawl		Dredge	Purse Seine				Other		
	LLS	PLL	GNS	DGN	TB	TM	LN	SUX	PSF	PSD	PSU	FPO	HAR/ MDV	LTL/ LHP/LHM
Caribbean/Gulf of Mexico	3	3	4	4	4	4	5	5	5	--	5	4	5	5
East Indian Ocean/Southeast Asia	2	2	3	3	4	4	5	5	5	--	5	5	5	5
Eastern Tropical Pacific/Southeast Pacific	2	2	1	1	2	2	5	4	4.5	5	5	4	5	4.5
Mediterranean	1	1	3	3	2	3.5	5	4	5	--	4	4	5	4.5
Northeast Atlantic	1	2.5	1	1	3	3	5	3	5	--	5	4	5	4.5
Northeast Pacific	1	1	3	3	3	3	5	4	5	--	5	4	5	4.5
Northwest Atlantic	3	3	3	3	4	3.5	4	4	5	--	5	4	5	4.5
Northwest Pacific	1	1	1	1	2	2	5	4	5	--	5	4	5	4.5
Oceania (Western Central Pacific)	4	2.5	3	3	5	5	5	5	4.5	--	4.5	5	5	5
Southern Ocean	1	1	--	--	2	2	5	5	5	--	5	5	5	5
West Africa /Southeast Atlantic	1	2.5	2	2	1	1	5	4	5	--	5	4	5	4.5
Southwest Atlantic	1	1	2.5	2.5	2	2	5	4	5	--	5	4	2	2
Southwest Pacific (Australia/New Zealand)	1	1	2	2	1	1	5	5	5	--	5	4	5	4.5
West Indian Ocean and Red Sea	2	2	1	1	3	3	5	4	5	--	5	4	5	4.5

***For known, unassessed spp., ≥3.5 = low concern**

Unknown Bycatch Matrix - sharks

Shark Bycatch Susceptibility

Region	Longline		Gillnet		Trawl		Dredge	Purse Seine				Other		
	LLS	PLL	GNS	DGN	TB	TM	LN	SUX	PSF	PSD	PSU	FPO	HAR/ MDV	LTL/ LHP/LHM
Caribbean/Gulf of Mexico	2	1	2	2	2	--	5	3.5	2	--	3	5	5	4
East Indian Ocean/Southeast Asia	3	3	2	2	1	1	5	3.5	1	--	2	5	5	3.5
Eastern Tropical Pacific/Eastern Pacific	1	1	2	2	1	2	5	3.5	1	3	2	5	5	3.5
Mediterranean/Black Sea	3	2	3	2	1	1	5	3.5	1	--	3	4	5	3.5
Northeast Atlantic	1	1	3	3	2	2	5	3.5	2	--	3	3	5	3.5
Northeast Pacific	1	1	2	2	1	2	5	3.5	2	--	3	5	5	3.5
Northwest Atlantic	1	1	3	3	1	1	5	3.5	2	--	3	5	5	3.5
Northwest Pacific	1	1	2	2	1	1	5	3.5	2	--	3	5	5	3.5
Oceania (Western Central Pacific)	1	1	3	3	2	2	5	3.5	1	--	2	5	5	3.5
Southern Ocean	4	4	--	--	2	4	5	3.5	5	--	5	5	5	3.5
West Africa/Southeast Atlantic	1	1	2	2	1	1	5	3.5	1	--	2	5	5	3
Southwest Atlantic	1	1	2	2	1	2	5	3.5	1	--	2	5	5	3.5
Southwest Pacific (Australia/New Zealand)	1	1	2.5	2.5	2	3	5	1	1	--	2	5	5	3.5
West Indian Ocean and Red Sea	3	2	1	1	2	2	5	3.5	1	--	2	5	5	3.5

***For known, unassessed spp., ≥3.5 = low concern**

Benthic invertebrates, finfish, forage fish, and corals

The values in the matrix of invertebrates, finfish, forage fish, and corals were developed initially by averaging the findings of two studies that ranked the relative ecological impacts of fishing gear (Fuller et al. 2008; Chuenpagdee et al. 2003). Some values in the matrix have been updated based on a survey of scientific experts on bycatch from around the world to increase the global relevance of the matrix.

The findings of the studies used to construct this matrix were pulled from literature searches, fisheries data and expert opinion. In general, these studies ranked the severity of fishing gear impacts as shown in this table (in order of severity):

Chuenpagdee et al 2003	**Fuller et al 2008**
Bottom trawl	Bottom trawl
Bottom gillnet	Bottom gillnet
Dredge	Dredge
Midwater gillnet	Bottom longline
Pot and traps	Midwater trawl
Pelagic longline	Pot and trap
Bottom longline	Pelagic longline
Midwater trawl	Midwater gillnet
Purse seine	Purse seine
Hook and line	Hook and line
	Dive
	Harpoon

Because these studies were based on fisheries operating in Canadian and United States waters, we also conducted a review of literature and expert opinion on bycatch severity by gear type from different regions of the world. Some of the initial values from Fuller et al. (2008) and Chuenpagdee et al. (2003) were adjusted accordingly. These changes are intended to better reflect the array of bycatch issues that occur using the same gear types in different regions of the world.

Bycatch severity for biogenic habitats (coral and sponges) by gear type was determined by averaging the values given in Fuller et al. (2008) and Chuenpagdee et al. (2003). Chuenpagdee et al. (2003), named this category "biological habitat" and Fuller et al. (2008) called it "coral and sponges." We did not change these values because it is likely that gear types that contact the bottom have the same potential for severe impacts throughout the world's oceans. Impacts from fishing on the benthos occur on virtually all continental shelves worldwide (Watling 2005).

We increased the number of trawl types from only bottom and midwater (used in both Fuller et al. (2008) and Chuenpagdee et al. (2003)) to also include bottom trawl categories for tropical/subtropical fish, tropical/subtropical shrimp, coldwater fish, and coldwater shrimp. Shrimp trawls are not designed to drag along the bottom and herd fish, so they receive a lower impact score in the matrix for finfish bycatch.

Other changes to the findings of Fuller et al. (2008) and Chuenpagdee et al. (2003) include separating the different purse seine techniques into FAD/log sets, dolphin/whale sets and unassociated school sets based on the variable bycatch rates found in a study by Hall (1998). Hall (1998) found that log (FAD) sets have the overall greatest bycatch for some species, followed by school sets and dolphin sets.

Bottom seines or demersal seines (including Danish seines, Scottish fly-dragging seines and pair seines) were not included in the Fuller et al. (2008) and Chuenpagdee et al. (2003) studies because these gear types are not commonly used in the U.S. or Canada. Like purse seines, these gear types encircle a school of fish, but they are operated in contact with the seafloor. A study by Palsson (2003) compared haddock discards among three demersal gear types in Icelandic waters and found fish bycatch to be lowest in Danish seines when compared with demersal trawls and longline gear. Danish seines targeting benthic fish species can incidentally catch non-target species such as flatfish, cod, and haddock (Icelandic Ministry of Fisheries 2010). Alverson et al. (1996) found that Danish seines generally fell into a low-moderate bycatch group of gear, with lower bycatch ratios than the majority of gear types, including bottom trawls, longlines and pots, but with higher bycatch than pelagic trawls and purse seines. Based on these findings, the bycatch score of Danish seines was estimated from the score for purse seines with an increase in the effects on shellfish to account for Danish seines being operated on the seafloor, an increase in the effect on finfish to account for greater bycatch of benthic fish such as flatfish, cod and haddock, and a decrease in the effect on forage fish, which are typically pelagic.

Unknown Bycatch Matrix – benthic invertebrates, finfish, forage fish, and corals and other biogenic habitats

Highest impacts receive a score of 1 and lowest impacts receive a score of 5. Key: B = Bottom, P = Pelagic, M = Mid-water, BTF = Bottom tropical fish, BTS = Bottom tropical shrimp, BCF = Bottom coldwater fish, BCS = Bottom coldwater shrimp, PF = Purse FAD/log (tuna), PD = Purse dolphin/whale (tuna), PU = Purse unassociated (tuna), Pot = Pot and trap, HD = Harpoon/diver, TP = Troll/pole and line

	Longline		Gillnet		Trawl						Dredge	Seine					Other		
	B	P	B	M	B	BTF	BTS	BCF	BCS	M		B	P	PF	PD	PU	Pot	HD	TP
Benthic Inverts	4.5	5	3	5	2	2	2	2	2	5	1	3	5	5	5	5	3.5	5	5
Finfish	2	2	2	1	2	1	2	2.5	2	1	3	2	4	2	3	2	3.5	5	3
Forage Fish	5	4	2	2	3	2	2	2	2	1	5	3	3	2	3	2	4	5	4
Corals and other biogenic habitats	3	5	2	5	1	1	1	1	1	5	1	1	5	5	5	5	3.5	5	4.5

Additional guidance for scoring unknown bycatch species in Criterion 1.1/2.1 (Abundance)

Sea turtles** – **all endangered/threatened: See Wallace et al. (2010, 2013) for global patterns of marine turtle bycatch. In addition, a global program, Mapping the World's Sea Turtles, created by the SWOT (State of the World's Sea Turtles) database is a comprehensive global database of sea turtle nesting sites around the world. The SWOT map is highly detailed and can be customized, allowing location filters and highlights of both species and colony size with variously colored and shaped icons. This map together with the paper by Wallace et al. (2010) can help to determine if the fishery being assessed has potential interactions with sea turtles.

Sharks, marine mammals and seabirds: Identify whether the fishery overlaps with any endangered/threatened or overfished species and err on the side of caution if species-specific and geographic information is inconclusive. For example, if shark populations are data deficient, err on the side of caution and rate as "overfished" or "depleted."

Sharks: Select "overfished" or "depleted" when data deficient or select "endangered/threatened" when data exist to support this (see Camhi et al. 2009). Globally, three-quarters (16 of 21) of oceanic pelagic sharks and rays have an elevated risk of extinction due to overfishing (Dulvy et al. 2008). See Camhi et al. (2009) for geographic areas, IUCN status and conservation concerns by shark species. Table 1 illustrates additional resolutions, recommendations and conservation and management measures by RFMO for sharks. Additional region and species-specific shark conservation information associated follows Table 1 in list format (Camhi 2009; Bradford 2010).

Marine mammals: The global distribution marine mammals and their important conservation areas are given by Pompa et al. (2011), who also used geographic ranges to identify 20 key global conservation sites for all marine mammal species (123) and created range maps for them (Figure 1; Table 2; Pompa et al. 2011 and supplement).

Seabirds: Figures 2 and 3 illustrate the distribution of threatened seabirds throughout the world (Birdlife International 2011). Also see Birdlife International (2010) to locate Marine Important Bird Areas (MIBA). Albatross are the most highly threatened family, with all 22 species either globally threatened or near threatened. The penguins and shearwaters/gadfly petrels also contain a high proportion of threatened species (Birdlife International 2010).

Table 1. Active resolutions, recommendations, and conservation and management measures by RFMO for sharks. Table from Camhi et al. (2009). [a] ICCAT = International Commission for the Conservation of Atlantic Tunas; NAFO = North Atlantic Fisheries Organization; GFCM = General Fisheries Commission for the Mediterranean; SEAFO = South East Atlantic Fisheries Organization; IATTC = Inter-American Tropical Tuna Commission; WCPFC = Western and Central Pacific Fisheries Commission; IOTC = Indian Ocean Tuna Commission; CCAMLR = Commission for the Conservation of Antarctic Marine Living Resources. [b] The weight of recommendations and resolutions varies by RFMO. For example, all ICCAT recommendations are binding, whereas resolutions are not.

Ocean/ RFMO[a]/Year	Res/Rec No.[b]	Title	Main actions
Atlantic, ICAAT			
1995	Res. 95-2	Resolution by ICCAT on cooperation with the FAO to study the status of shark stocks and by-catches	• Urges members to collect species-specific data on biology, bycatch and trade in shark species and provide these data to FAO
2003	Res. 03-10	Resolution by ICCAT on the shark fishery	• Requests all members to submit data on shark catch, effort by gear, landings and trade in shark products • Urges members to fully implement a NPOA
2004	Rec. 04-10	Recommendation by ICCAT concerning the conservation of sharks caught in association with fisheries managed by ICCAT	• Requires members to annually report shark catch and effort data • Requires full utilization • Bans finning • Encourages live release • Commits to reassess shortfin mako and blue sharks by 2007 • Promotes research on gear selectivity and identification of nursery areas
2005	Rec. 05-05	Recommendation by ICCAT to amend Recommendation 04-10 concerning the conservation of sharks caught in association with fisheries managed by ICCAT	• Requires annual reporting of progress made toward implementation of Rec. 04-10 by members • Urges member action to reduce North Atlantic shortfin mako mortality
2006	Rec. 06-10	Supplementary recommendation by ICCAT concerning the conservation of sharks caught in association with fisheries managed by ICCAT	• Acknowledges little progress in quantity and quality of shark catch statistics • Reiterates call for current and historical shark data in preparation for blue and shortfin mako assessments in 2008
2007	Rec. 07-06	Supplemental recommendation by ICCAT concerning sharks	• Reiterates mandatory data reporting for sharks • Urges measures to reduce mortality of targeted porbeagle and shortfin mako • Encourages research into nursery areas and possible time and area closures • Plans to conduct porbeagle assessment no later than 2009
2008	Rec. 08-07	Recommendation by ICCAT on the conservation of bigeye thresher sharks (*Alopias superciliosus*) caught in association with fisheries managed by ICCAT	• Urges live release of bigeye thresher sharks to the extent practicable • Requires bigeye shark catches and live releases be reported

Atlantic, NAFO			
2009	Mgt. Measure Article 17	Conservation and management of sharks	• Requires reporting of all current and historical shark catches • Promotes full utilization • Bans finning • Encourages live release • Promotes research on gear selectivity and identification of nursery areas
Atlantic, SEAFO			
2006	Conservation measure 04/06	Conservation measure 04/06 on the conservation of sharks caught in association with fisheries managed by SEAFO	• Same provisions as ICCAT Rec. 04-10, except does not include stock assessments
Med., GFCM			
2005	GFCM/2005/3	Recommendation by ICCAT concerning the conservation of sharks caught in association with fisheries managed by ICCAT	• Same provisions as ICCAT Rec. 04-10
2006	GFCM/2006/8(B)	Recommendation by ICCAT to amend Recommendation [04-10] concerning the conservation of sharks caught in association with fisheries managed by ICCAT	• Same provisions as ICCAT Rec. 05-05
Indian, IOTC			
2005	Res. 05/05	Concerning the conservation of sharks caught in association with fisheries managed by IOTC	• Requires members to report shark catches annually, including historical data • Plans to provide preliminary advice on stock status by 2006 • Requires full utilization and live release • Bans finning • Promotes research on gear selectivity and to ID nursery areas
2008	Res. 08/01	Mandatory statistical requirements for IOTC members and cooperating non-contracting parties (CPCs)	• Requires members to submit timely catch and effort data for all species, including commonly caught shark species and less common sharks, where possible
2008	Res. 08/04	Concerning the recording of catch by longline fishing vessels in the IOTC area	• Mandates logbook reporting of catch by species per set, including for blue, porbeagle, mako and other sharks

Pacific, IATTC			
2005	Res. C-05-03	Resolution on the conservation of sharks caught in association with fisheries in the Eastern Pacific Ocean	• Promotes NPOA development among members • Work with WCPFC to conduct shark population assessments • Promotes full utilization • Bans finning • Encourages live release and gear-selectivity research • Requires species-specific reporting for sharks, including historical data
2006	Res. C-04-05 (REV 2)	Consolidated resolution on bycatch	• Requires prompt release of sharks, rays and other non-target species • Promotes research into methods to avoid bycatch (time-area analyses), survival rates of released bycatch and techniques to facilitate live release • Urges members to "provide the required bycatch information as soon as possible"
Pacific, WCFPC			
2008	Cons. & Mgt. Measure 2008-06 (replaces 2006-05)	Conservation and management measure for sharks in the Western and Central Pacific Ocean	• Urges members to implement the IPOA and report back on progress • Requires annual reporting of catches and effort • Encourages live release and full utilization • Bans finning for vessels of all sizes • Plans to provide preliminary advice on stock status of key sharks by 2010
Southern, CCAMLR			
2006	32-18	Conservation of sharks	• Prohibits directed fishing of sharks • Live release of bycatch sharks

Additional shark information and citations (Bradford 2010)

- In the Gulf of Mexico, Baum and Myers (2004) found that between the 1950s and the late-1990s, oceanic whitetip and silky sharks (formerly the most commonly caught shark species in the Gulf of Mexico) declined by over 99 and 90%, respectively.
- In the Northwest Atlantic, Baum et al. (2003) estimated that scalloped hammerhead, white, and thresher sharks had declined by over 75% between the mid-1980s and late-1990s. The study also found that all recorded shark species in the Northwest Atlantic, with the exception of mako sharks, declined by over 50% during the same time period.
- Myers et al. (2007) reported declines of 87% for sandbar sharks, 93% for blacktip sharks, 97% for tiger sharks, 98% for scalloped hammerheads, and 99% or more for bull, dusky, and smooth hammerhead sharks along the Eastern seaboard since surveys began along the coast of North Carolina in 1972.
- The International Union for the Conservation of Nature (IUCN) has declared that "32% of all pelagic sharks and rays are threatened." The IUCN has declared another 6% to be Endangered, and 26% to be Vulnerable.
- In the Mediterranean Sea, Ferretti et al. (2008) found that hammerhead, blue, mackerel, and thresher sharks have declined between 96 and 99.99% relative to their former abundance levels.
- Ward and Myers (2005) report a 21% decline in abundance of large sharks and tunas in the tropical Pacific since the onset of commercial fishing in the 1950s.
- Meyers and Worm (2005) indicate a global depletion of large predatory fish communities of at least 90% over the past 50–100 years. The authors suggest that declines are "even higher for sensitive species such as sharks."
- Dulvy et al. (2008) state that "globally, three-quarters (16 of 21) of oceanic pelagic sharks and rays have an elevated risk of extinction due to overfishing."
- Graham et al. (2001) found an average decrease of 20% in the catch rate of sharks and rays off New South Wales, Australia, between 1976 and 1997.

Table 2. Marine mammal species in important conservation sites. "Irreplaceable areas" contain species found nowhere else. Figures from Pompa et al. (2011; supplt. material). [1]*Monachus schauinslandi*, [2]*Arctocephalus galapagoensis*, [3]*A. philippii*, [4]*Inia geoffrensis*, *Trichechus inunguis* (both freshwater) and *Sotalia fluviatilis*, [5]*Monachus monachus*, [6]*Platanista minor* (freshwater), [7]*Platanista gangetica* (freshwater), [8]*Lipotes vexillifer* (freshwater), [9]*Pusa sibirica* (freshwater), [10]*Pusa caspica*, [11]*Cephalorhynchus commersonii* and *A. gazella.* *VU = Vulnerable, EN = Endangered, CR = Critically

Endangered, LR = Lesser Risk, EX = Extinct, CE = Critically Endangered; V = Vulnerable, RS = Relatively Stable or Intact. Data from Olson and Dinerstein (2002).

Key conservation sites	Number of species	Endemic/ small-range	Risk category for each ecoregion*	Number and name of the ecoregion*	Estimated conservation status of the ecoregion*
Highest richness					
South African	16	4	VU, EN	209: Benguela Current 211: Agulhas Current	V RS
Argentinean	15	4	VU, EN	205: Patagonian Southwest Atlantic	V
Australian	14	4	VU, EN	206: Southern Australian 222: Great Barrier	RS RS
Baja Californian	25	7	VU, EN, CR	214: Gulf of California	CE
Peruvian	19	5	VU, EN	210: Humboldt Current	V
Japanese	25	7	VU, EN, LR	217: Nansei Shoto	CE
New Zealand	13	2	VU, EN, LR	207: New Zealand	V
Northwestern African	25	7	VU, EN, LR	216: Canary Current	CE
Northeastern American	25	7	VU, EN, LR	202: Chesapeake Bay	V
Irreplaceable					
Hawaiian Islands	1[1]	1	EN	227: Hawaiian Marine	V
Galapagos Islands	1[2]	1	VU	215: Galapagos Marine	V
San Félix and Juan Fernández Islands	1[3]	1	VU	210: Humboldt Current	V
Amazon River	2[4]	1	VU	147: Amazon River/Flooded Forests	RS
Mediterranean Sea	1[5]	1	CR	199: Mediterranean Sea	CE
Indus River	1[6]	1	Not Listed	Not Listed	Not Listed
Ganges River	1[7]	1	EN	Not Listed	Not Listed
Yang-tse River	1[8]	1	EX	149: Yang-Tse River And Lakes	CE
Baikal Lake	1[9]	1	LR	184: Lake Baikal	V
Caspian Sea	1[10]	1	VU	Not Listed	Not Listed
Kerguelen Islands	1[11]	1	Not Listed	Not Listed	Not Listed

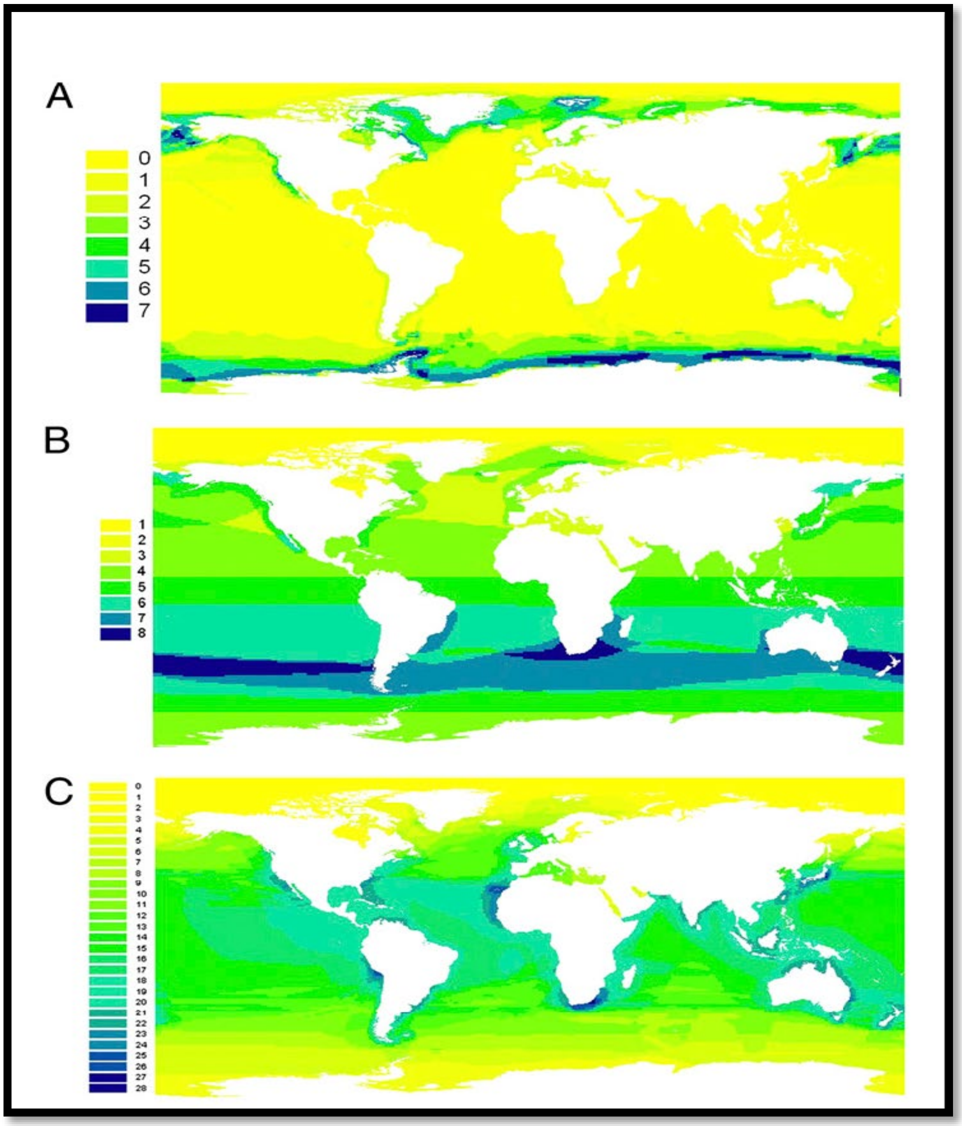


Figure 1. Geographic distribution of marine mammal species richness (left column) for **A**. Pinnipeds; **B**. Mysticetes; **C**. Odontocetes. Figure from Pompa et al. (2011).

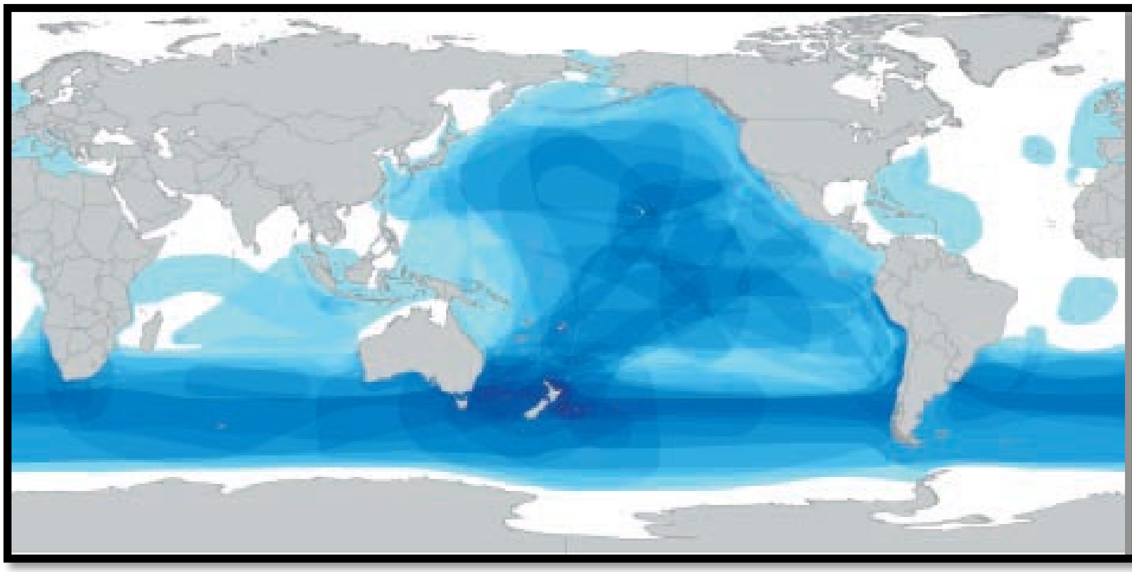


Figure 2. At-sea distribution of threatened seabirds around the globe. Each polygon represents the range map for one threatened species. Areas of darkest blue show the areas of the ocean where the ranges of the greatest number of threatened species overlap. Figure from Birdlife International (2011).

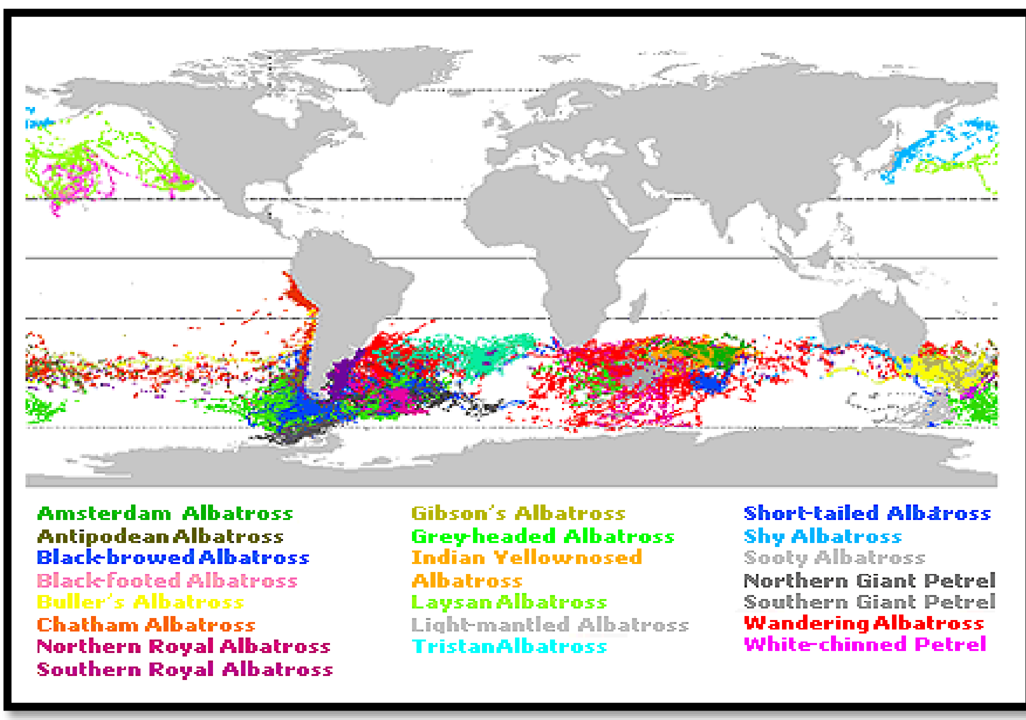


Figure 3. Worldwide distribution of albatross and petrels. Figure from Birdlife International (2011).

Appendix 3 – Appropriate management strategies

Appropriate management procedures may vary greatly between different fisheries, regulatory frameworks and species. To some extent, assessment of harvest control rules and other management strategies must therefore be addressed on a case-by-case basis. However, general guidelines for appropriate management are still relevant and useful. For fisheries managed using catch limits or TACs, these guidelines have been derived largely from the guidance provided for implementation of the Magnuson-Stevens Fishery Conservation and Management Act used for fishery management in the U.S. (Restrepo and Powers 1998; Restrepo et al. 1998). While other countries have different regulatory frameworks, similar strategies to those suggested in Restrepo et al. (1998) are used throughout the world where stock assessments are available and catch limits are employed (*e.g.*, Australian Department of Agriculture, Fisheries and Forestry 2007; NZ Ministry of Fisheries 2008; DFO 2009). Commonly accepted strategies include setting fishing mortality rates safely below F_{MSY} (or other appropriate reference point) to account for uncertainty; reducing F when stocks fall below biomass target reference points (generally around B_{MSY} or 40% of unfished biomass); and reducing fishing mortality when stock falls below a critical level where recruitment is impaired. Management reference points are assumed to be valid unless scientific information exists to suggest otherwise, *e.g.*, a scientific assessment or controversy that strongly suggests current reference points are not appropriate for the species under assessment.

In general, the minimal attributes of an appropriate management strategy include:

1. A process for monitoring and conducting "assessments" (not necessarily formal stock assessments). Monitoring should occur regularly, though the frequency of assessments needed may vary depending on the variability of the stock.
2. Rules that control the intensity of fishing activity or otherwise ensure the protection of stock productivity.
3. A process to modify rules according to assessment results, as needed.

Some effective management strategies

For data-rich or data-moderate stocks that have quota-based management, a "highly effective" management strategy is one that:

- Incorporates an up-to-date, scientific stock assessment that allows managers to determine if stocks are healthy and to set appropriate quotas;
- Uses appropriate limit and target reference points for stock and fishing mortality;
- Chooses risk-averse policies rather than risky, yield-maximizing policies;
- Includes buffers in the TAC to account for uncertainty in stock assessments
    - Set Allowable Biological Catch (ABC) and Annual Catch Limit (ACL) at less than the Over-Fishing Level (OFL = long term mean of MSY) to account for scientific uncertainty (survey data on stock size, etc. can reduce scientific uncertainty);
    - Set Total Allowable Catch (TAC) at less than ABC to account for management uncertainty (monitoring catch, etc. can reduce management uncertainty);
    - As a rule of thumb, TAC should have less than 30% p* (likelihood) of exceeding OFL; or TAC should be set such that F is 25% below the threshold fishing pressure, *e.g.* F_{MSY} (Restrepo et al. 1998)

    - Stocks with low biomass, high vulnerability, and high uncertainty warrant greater protection against overfishing (*e.g.*, more conservative harvest control rules/ greater buffers in setting TAC and/or closer monitoring of stocks).
- Takes into account other sources of mortality (*e.g.*, recreational fishery, bycatch of juveniles, etc.) and environmental factors that affect stock, such as oceanographic regime;
- Incorporates a strategy for maintaining or rebuilding stock productivity:
    - A no-fishing point when biomass is below the limit reference point;
    - A decrease in F when biomass is below the target reference point or is declining (whether declines are due to fishery or environmental factors).
- Employs an effective strategy to prevent overcapitalization;
- Has been demonstrated effective (*e.g.*, stock productivity has been maintained over multiple generations), or if stock productivity has not been maintained or is declining, have adjusted management accordingly.

Effective management in data-limited fisheries
(more information on data-limited evaluation methods below)

Whether managed stocks are data-rich or data-limited, management must include a strategy to ensure that stock productivity is maintained in order to be considered effective. This strategy should include a process for monitoring and conducting "assessments" of some kind (not necessarily formal stock assessments), rules that control the intensity of fishing activity or otherwise ensure the protection of a portion of the spawning stock, and a system of adaptive management, such that rules are modified according to assessment results, as needed (Smith et al. 2009; Phipps et al. 2010).

There are some relatively reliable methods for setting catch limits in data-limited fisheries, including: An Index Method (AIM), which involves fitting a relationship between population abundance indices and catch; Depletion-Corrected Average Catch (DCAC), which allows managers to estimate a sustainable yield based on average catch over a set time period, adjusting for initial declines in abundance due to harvesting; and extrapolation methods, or relying on inferences from related or "sister" stocks, with the use of precautionary buffers in case the data-limited stocks are more vulnerable than the related data-rich stocks (Honey et al. 2010). Other techniques recommended for data-limited stocks include the use of productivity-susceptibility analysis (PSA) to highlight stocks that are particularly vulnerable to over-exploitation (Patrick et al. 2009; Honey et al. 2010) and setting catch limits based on historical catch from a period of no declines, with targets set at 75% of average catch if biomass is believed to be healthy, 50% of average catch if biomass is expected to be below target levels but above the point where recruitment would be impaired, and 25% of average catch if the stock is depleted (Restrepo and Powers 1998).

Other than constraining fishing mortality (*e.g.*, through TACs), fisheries may be credited for employing alternative strategies that are widely believed to be help maintain stock productivity. Some examples of effective alternative strategies are spatial management, including protecting a large proportion of coastline in reserves and/or protecting known spawning aggregations with seasonal or spatial closures (*e.g.*, Johannes 1998), or protecting females, which preserves the spawning per recruit of the population as long as fertilization does not decrease (*e.g.*, Dungeness crab; Chaffee et al. 2010). Finally, stocks may be subject to low mortality in a data-limited fishery as a result of low susceptibility, *e.g.*, if the species is small enough to fit between the mesh of the nets or is not attracted to the type of bait used (low susceptibility is generally more applicable as protection for non-target stocks).

Management of data-limited stocks – alternatives to MSY-based management

For data-limited stocks, management should:

- Include a process for monitoring and assessment, such as recording trends in CPUE and size structure, or estimating FLEP, or comparison of abundance index to historical high (see glossary), unfished, or marine reserve levels:
    - Trends in CPUE are appropriate only if technology has not changed, there is no hyperstability, and abundance is shown to be proportional to CPUE;
    - Trends in size structure must also be monitored to avoid depletion of large individuals.
- Include a strategy for protecting spawning stock, such as:
    - Estimate sustainable yield based on Depletion Corrected Average Catch (DCAC), An Index Method (AIM), or another accepted strategy;
    - Protect a large portion of spawning stock in marine reserves (at least 50%, including important spawning areas if applicable) or close hotspots to fishing (for bycatch species);
    - Enforce size, sex, and/or season limitations that are likely to be effective in protecting spawning stock productivity (*e.g.*, Dungeness crab 3-S management);
    - Extrapolate based on data-rich related or "sister" stocks, with precautionary buffers in place to account for potential differences in the stocks' life histories;
    - Maintain exploitation rates at very low levels (*e.g.*, experimental fishery) until more data can be collected, **or**
    - Base TAC on average historical catch during a period of time with no declines in abundance (TAC should be set at no more than 75% of average catch if stock is believed to be healthy, 50% if believed to be below target levels, and 25% if believed to be overfished. *Note:* as there is generally no data to assess whether a stock is healthy, TAC should not be more than 50% of historical catch unless there is a strong scientific reason to believe that stocks are above B_{MSY}).
- Allow for adaptive management so that fishing strategy is adjusted if assessment/monitoring indicates that stock is declining or below target levels;
- Have been demonstrated effective (*e.g.*, stock productivity has been maintained over multiple generations) **or**, if stock productivity has not been maintained or is declining, management has been adjusted accordingly.

Procedures for monitoring/assessing stocks and procedures for protecting spawning stock must be in place, and be demonstrated effective, to qualify management strategy as "highly effective." If measures are expected to be effective, *e.g.*, through analogy with similar systems, but have not been demonstrated effective in this fishery, management is "moderately effective." If measures are not expected to be effective, management strategy is "ineffective."

Appropriate management also depends on the conservation concern associated with the stock. In addition to the precautionary elements listed above, stocks that are endangered or threatened also require a recovery plan and/or best management practices designed and demonstrated to reduce mortality and allow the stock to recover. Overfished and depleted stocks require a rebuilding plan.

Data-limited fishery evaluation methods

Sequential trend analysis (index indicators)

Sequential analysis comprises a broad suite of techniques used to analyze time series data in order to detect trends in a variable (or in various indices) and infer changes in the stock or population. Sequential analyses can encompass a wide range of data types and requirements (Honey et al. 2010). Examples include: DCAC, time series of catch statistics, survey/weight/length-based reference points, trophic indices, and spawning potential ratio (SPR) analogues (Honey et al. 2010).

Depletion-corrected average catch (DCAC) uses only catch time-series data supplemented with educated guesses for a few supplementary parameters. Therefore, it is likely of practical use for many data-limited fisheries on long-lived species (*e.g.*, natural mortality, M < 0.2) (Honey et al. 2010). The ability of this method to identify sustainable yields from simple data input makes DCAC useful as a first-step estimate for an allowable catch level along with other data-limited methods. See: http://nft.nefsc.noaa.gov/ for the NOAA toolbox to perform DCAC analysis (Honey et al. 2010).

Vulnerability analysis

Productivity and susceptibility analysis of vulnerability – The Productivity-Susceptibility Analysis of vulnerability (PSA) method is used to assess a stock's vulnerability to overfishing, based on relative scores derived from life-history characteristics. Productivity, which represents the potential for stock growth, is rated semi-quantitatively from low to high on the basis of the stock's intrinsic rate of increase (*r*), von Bertalanffy growth coefficient (*k*), natural mortality rate (*M*), mean age at maturity, and other metrics (Patrick et al. 2009; Patrick et al. 2010; Field et al. 2010; Cope et al. 2011; Honey et al. 2010).

To assist regional fishery management councils in determining vulnerability, NMFS elected to use a modified version of a productivity and susceptibility analysis (PSA) because it can be based on qualitative data, has a history of use in other fisheries, and is recommended by several organizations as a reasonable approach for evaluating risk (Patrick et al. 2010). Patrick et al. (2010) evaluated six U.S. fisheries targeting 162 stocks that exhibited varying degrees of productivity and susceptibility, and for which data quality varied. Patrick et al. (2010) found that PSA was capable of differentiating the vulnerability of stocks along the gradient of susceptibility and productivity indices. The PSA can be used as a flexible tool capable of incorporating region-specific information on fishery and management activity. Similar work was conducted by Cope et al. (2011) who found that PSA is a simple and flexible approach to incorporating vulnerability measures into complex stock designations while also providing information helpful in prioritizing stock- and complex-specific management.

Extrapolation (Robin Hood Method)

When very limited or no data are available for a stock or specific species in a region, then managers may need to rely on extrapolation methods to inform decisions. Often, low-value stocks are data-limited (Honey et al. 2010). This method is termed the "Robin Hood" approach in Australia because it takes information and scientific understanding in data-rich fisheries and "gives" inferences to the data-limited fisheries (Smith et al. 2009). Data may include: (1) the local knowledge of the fishers and resource users; and/or (2) scientific research and ecosystem understanding from "sister" systems thought to be similar (Honey et al. 2010). Extrapolation from similar systems or related species may offer an informed starting point from which managers can build precautionary management (Honey et al. 2010). In these situations, life-history characteristics, potentially sustainable harvest levels, spawning behavior, and other information can be gleaned from nearby stocks, systems, or related species (Honey et al. 2010).

Decision-making methods

Decision trees

Decision trees provide systematic, hierarchical frameworks for decision-making that can scale to any spatial, temporal, or management context in order to address a specific question. A decision tree may be customized to meet any need (Honey et al. 2010). Trees may include: identification of reference points based on stock characteristics and vulnerability (Cope and Punt 2009); fostering of fine-scale, transparent, and local management (Prince 2010); and, estimation and refinement of an appropriate Total Allowable Catch (TAC) level (Wilson et al. 2010).

Management strategy evaluation

Management Strategy Evaluation (MSE) is a general modeling framework designed for the evaluation of performance of alternative management strategies for pursuing different objectives (Honey et al. 2010). This approach simulates the fishery's response to different management strategies (*e.g.*, different TAC levels, seasonal closures, or other effort reductions) (Honey et al. 2010). Assuming sufficient quality data exist, MSE may be useful for assessing the effectiveness of different policy options (Honey et al. 2010).

In addition, a study by Dowling et al. (2008) developed harvest strategies for data-limited fisheries in Australia. Strategies included: (i) the development of sets of triggers with conservative response levels, with progressively higher data and analysis requirements at higher response levels, (ii) identification of data gathering protocols and subsequent simple analyses to better assess the fishery, (iii) the archiving of biological data for possible future analysis, and (iv) the use of spatial management, either as the main aspect of the harvest strategy or together with other measures (Honey et al. 2010).

Cooperative research and co-management to overcome data-limited situations

A recent study by Fujita et al. (2010) identified opportunities for cooperative research and co-management that would complement (but not replace) existing top-down fishery regulations. They conclude that management and data collection would improve for some small-scale fisheries if they started: collecting data at the appropriate spatial scales; collecting local information, improving the quality of data, and overcoming constraints on data; providing ecosystem insight from a small/local scale for new and different perspectives; reducing conflicts among fishermen, scientists, and regulators; and improving the responsiveness of fisheries management to local needs. Fujita et al. (2010) suggest that scientists and managers should further develop cooperative strategies (*e.g.*, cooperative research and co-management) and include them in the management framework.

Salmon Fisheries

Salmon from one population are often found co-mingled or co-migrating with salmon from a different population of the same species. This can lead to particular challenges when managing salmon fisheries and the impacts that these fisheries have on different populations. This is a particular concern where abundant stocks are migrating alongside depleted stocks, which may be listed as Endangered or Threatened under the ESA. Fishery managers have a responsibility to protect the ESA listed stocks, while also allowing harvest of abundant stocks. Several measures can be taken by managers to reduce the impact on ESA listed stocks, such as temporal and spatial closures when ESA listed stocks are at risk of capture. Such mitigation measures, their application, and the success of such measures should be considered in Factor 3.1 when assessing salmon fisheries, because the purpose of the measures are to avoid the capture of low abundance stocks to aid their recovery. For further guidance, see Appendix 8.

Effective management of a fishery on a non-native species

Effective management of a fishery for a non-native species may include:

- Mitigation strategies aimed at eradication, reversing establishment, or maintenance at low abundance, as deemed appropriate and feasible for that particular case;
- Adaptation strategies that allow for recovery of species impacted by the non-native species;
- Containment measures such as fishing at the boundaries of the stock to prevent further spread, and/or
- Provisions to prohibit further introductions of any other alien species.

Management strategies to minimize discarding

Discarding of catch can occur for a variety of reasons, including but not limited to low commercial value and falling outside of regulatory requirements (for example, below a minimum landing size or no quota availability). Discarding is a wasteful practice that is undesirable to both fishers and managers alike. There are a number of strategies that can be employed around the world to minimize discarding: The use of bycatch reduction devices (BRDs) can reduce the catch of undersized individuals of the target species and smaller species of fish and have been used to some success in the Gulf of Mexico shrimp trawl fleet. In an attempt to better quantify the impact of fisheries on all fish stocks within the catch, some fisheries are moving to a zero-discard strategy which requires all fish caught to be landed. Typically, these approaches require high levels of observer coverage or electronic monitoring solutions to ensure compliance.

Many discard avoidance or mitigation strategies will relate to bycatch species and should be considered under factor 3.2; however, it is also important to consider the impact of discarding on the retained species (for example the discarding of undersized individuals as a result of regulation or high-grading) and any measures that have been introduced to mitigate/address these concerns. Such measures should be discussed in factor 3.1.

Flexible and Resilient fisheries management in the face of climate change

This section is a work in progress and will be expanded in the future. Seafood Watch will provide guidance to its analysts on principles and practices of flexible and resilient fisheries management strategies to be applied in Criterion 3. This will be particularly useful when the species' (and their habitats and the ecosystems) under assessment are or may be impacted by climate change, which includes forage species.

The concept of resilience in fisheries management focuses on how to build capacity that can buffer the impacts of unexpected (or predicted/expected) changes before they occur. While it is often ideal for management to anticipate changes, it is often the case that management responds to change once it has occurred. Seafood Watch accepts reactive management as potentially highly effective, as long as it is implemented in an appropriate timeframe (for example, before a stock falls below a critical biomass such that recovery does not or is likely not to occur)

Below are examples of reactive strategies that are a response to change after it has occurred and proactive strategies that plan for changes that may occur and which promote resilience of stocks and ecosystems. These are adapted from Morrison and Termini 2016. This list provides examples, and is not intended as a comprehensive list of strategies to manage for resilience. Due to the diversity of fishery and ecosystem characteristics that may be encountered it is important to consider each one on a case by case basis. Further guidance will be provided as scientific understanding in this area develops.

Management profile	**Management strategies**
Reactive	Flexible management systems are in place (systems that identify when management changes are needed and are able to implement these changes in a timely manner)
	Reference Points are adjustable after changes in species productivity or stock structure occurred
	Fisheries Allocations can be adjusted (if species abundances or distributions changed)
	Fishing practices or gears are adjusted (as Fish Community Composition Changes)
Proactive management that increase species' resilience	Managing for uncertainty- Scenario Planning
	Managing to promote adaptive capacity
	Protecting age structure and/or old females
	Incorporating environmental parameters into stock assessments and management measures
	Decreasing existing stressors
	Enhancing or translocating stocks
Proactive management that increase ecosystem resilience	Protecting key habitats and species
	Applying ecosystem models to better understand species' responses
	Designing appropriate marine reserves

Appendix 4 – Bycatch reduction approaches

In general, fisheries should address bycatch with the following approaches:

- Monitor bycatch rates (using adequate observer coverage),
- Have some scientific assessment of impacts on bycatch populations
- Incorporate strategies that assure bycatch is minimized, such as:
    - Enforcing effective and appropriate bycatch caps,
    - Closing hotspots or implementing seasonal closures,
    - Promoting effective gear modifications such as BRDs, TEDs, etc.
    - Adopting bycatch-reducing strategies such as night setting,
    - Using the best available management techniques that have been demonstrated in this or a similar system to effectively constrain bycatch rates.

The effectiveness of various bycatch reduction approaches is synthesized from primary literature and reviewed below. To be considered "highly effective", all required measures and at least one primary measures should be in place.

Seabird sources are Løkkeborg (2008) (general conclusions and Table 3, including percent effectiveness of some modification/region strata) and SBWG 2010 (Annexes 3–8). *Secondary measures may be useful in conjunction with primary measures. Turtle sources are FAO 2009 (Tables 1 and page 79) and Gilman and Lundin (2008) (Table 3). Shrimp trawl modifications sources are Eayers 2007 and Gillet 2008 (Box 14). Sharks and marine mammals from Gilman and Lundin (2008) (Table 3). General information on fishing technologies can be found at http://www.fao.org/fishery/en, and a list of bycatch reduction literature can be found here: http://www.bycatch.org/articles.

Gear/taxon/modification	Primary/ secondary measure*	Effectiveness/notes
General strategies (good for all gears/taxa)		
Monitoring and compliance	Require-ment	Considerable difference between experimental and real-world effectiveness. “Three common themes to successful implementation of bycatch reduction measures are long-standing collaborations among the fishing industry, scientists, and resource managers; pre- and post-implementation monitoring; and compliance via enforcement and incentives” (Cox, Lewison et al. 2007).
Avoid bycatch hotspots	Primary	Area/time closures. Generally, very effective, though more so when based on data such as tagging or bycatch data. Perhaps only a secondary mitigation measure for birds (Løkkeborg 2008). Alternatively, move when interaction rates are high. Effective for all fisheries, especially with fleet communication. Closures for one taxon without commensurate reduction in effort can increase bycatch of other taxa.
Bycatch caps	Primary	*I.e.,* fishery closes when cap exceeded.
Bycatch fees, Compensatory Mitigation Strategies for Marine Bycatch (CMSMB)	Secondary, at best	Not effective. “We conclude that, overall, CMMB has little potential for benefit and a substantial potential for harm if implemented to solve most fisheries bycatch problems. In particular, CMMB is likely to be effective only when applied to short-lived and highly fecund species (not the characteristics of most bycatch-impacted species) and to fisheries that take few non-target species, and especially few non-seabird species (not the characteristics of most fisheries). Thus, CMMB appears to have limited application and should only be implemented after rigorous appraisal on a case-specific basis; otherwise it has the potential to accelerate declines of marine species currently threatened by fisheries bycatch” (Finkelstein, Bakker et al. 2008). May be useful, but only as a complementary measure (Žydelis, Wallace et al. 2009).
Pelagic longline		
Seabirds (albatrosses and petrels)	Best	No single solution to avoid incidental mortality of seabirds in pelagic longline fisheries. Most effective approach is streamer lines combined with branchline weighting and night setting. Best practices are followed for line setting and hauling (*e.g.*, SRWG 2010).
Night setting	Primary	Proven effective in Southern Hemisphere. Streamer lines and weighted lines should also be used when interacting with nocturnal birds/fishing during bright moon.
Streamer/scarer lines	Primary	Proven to be effective in North Atlantic. Should be paired and/or weighted lines in North Pacific. Paired lines need more testing. Light configuration not recommended.
Weighted branch lines	Primary	Must be combined with other measures.
Offal discharge management	Secondary	Not yet established but is thought to assist.
Sidesetting	Secondary	Insufficiently researched; there have been operational difficulties on some vessels. Effective in Hawaii in conjunction with bird curtain and weighted branch lines. Japanese research conclusions must be combined with other measures. Untested in Southern Hemisphere.

Line shooter and mainline tension, bait caster, live bait, thawing bait	-	Not recommended.
Underwater setting chute, hook design, olfactory deterrents, blue-dyed bait	-	Insufficient research. Blue-dyed bait may be only effective with squid bait. Results inconsistent across studies.
Turtles		
Replacement of J and tuna hooks with circle hooks	Primary	Wide circle hook with </= 10-degree offset.
Bait change	Primary	Use of fish instead of squid.
Deep setting	Primary	Set gear deeper than turtle abundant depths (40–100m).
Fish bait hooking	Primary	Single hooking fish bait instead of threading hook through bait multiple times.
Temporal changes	Primary	Reduce soak time and haul during daylight.
Lights on gear	Secondary	Use of intermittent flashing light sticks instead of continuous use non-luminous gear.
Handling and release practices	Primary	To reduce mortality of caught turtles.
Sharks		
Bait change	Primary	Fish instead of squid.
Prohibit wire leaders	Primary	
Deeper setting	Primary	Avoid surface waters.
Shark repellants	-	Insufficient research.
Circle hooks		
Marine mammals		
Weak hooks, deterrents, echolocation disruption	-	Insufficient research.
Other finfish (including juvenile targets)		
Circle hooks		May help reduce mortality of billfish and tunas.
Shellfish		
Not problematic		
Bottom longline (Many measures similar to pelagic longline)		
Seabirds (albatrosses and petrels)	Best	No single solution to avoid incidental mortality of seabirds in demersal longline fisheries. No combination specified: assume streamers, weighted and night setting, or Chilean longline method (vertical line with very fast sink rates—considered effective even without other measures; widely used in South American waters and SW Atlantic). Best practices are followed for line setting and hauling (*e.g.*, SRWG 2010).
Streamer/scarer lines	Primary	Effective, but must be used properly (streamers are positioned over sinking hooks). Better when combined with, *e.g.*, night setting, weighting, or offal control.
Weighted lines	Primary	Must be combined with other measures, especially streamers, offal control and/or night setting.
Night setting	Primary	Same as pelagic.

Haul curtain (reduce bird access when line is being hauled)	Secondary	Can be effective but must use strategically as some birds become habituated. Must be used with other measures.
Offal discharge control (discharge homogenized offal at time of setting)	Secondary	Must be used in a combo, *e.g.*, with streamers, weighting, or night setting.
Side setting	Secondary	Insufficiently researched; there have been operational difficulties on some vessels.
Hook design, olfactory deterrents, underwater setting chutes, blue-dyed bait, thawed bait, use of line setter	-	Insufficiently researched. Blue-dyed bait, thawed bait, and use of line setter not relevant in demersal gear.
Turtles, sharks, mammals, other finfish, shellfish		
See pelagic longlines		
Trawl		
Seabirds (albatrosses and petrels)	Best	Little work has been done on seabird bycatch mitigation in trawl fisheries (pelagic and demersal). There is no single solution to avoid incidental mortality of seabirds in trawl fisheries. The most effective approach is offal discharge and discards control, through full retention of all waste or mealing (the conversion of waste into fish meal reducing discharge into sump water) plus streamer lines. Effectiveness of other offal control measures such as mincing and batching is not clear.
Limited waste control	Minimum requirement for + modifier	No discharge of offal or discards during shooting and hauling.
Reduce cable strike through bird scaring wires or snatch block	Primary	Scarers recommended even when offal/discard management is in place. Snatch block recommended on theory.
Reduce net entanglement through net binding, net weights, net cleaning		Recommended on theory.
Net jackets	-	Not recommended.
Reduced mesh size, acoustic scarers, warp scarers, bird bafflers, cones on warp cables	-	Effectiveness not yet established.
Turtles		

Turtle excluder device (TED)	Primary	Any modification to the trawl to reduce the capture of turtles, principally in tropical/subtropical shrimp trawls. Typically a grid or large-hole mesh designed to prevent turtles from entering the codend. The only designs approved for use in the US warm-water shrimp fisheries are hard TEDs (*i.e.,* "hooped hard TEDs" such as NMFS, Coulon and Cameron TEDs, "single grid hard TEDs" such as the Matagorda, Georgia, or Super Shooter TED, and the Weedless TED) and the Parker Soft TED (the latter only in offshore and inshore waters in Georgia and South Carolina). Hard TEDs that are not approved for use in the shrimp fisheries are used in the Atlantic summer flounder bottom trawl fishery. TEDs must be used in conjunction with escape hatches, which also vary in size and design. More details on TED/hatch designs and US regulations can be found in Eayers (2007).
Sharks		
TED		TEDs generally allow large animals to escape, *e.g.*, sharks (Belcher and Jennings 2010). Highly variable depending on net type and TED used. BRD made little difference (fisheye).
Marine mammals		
TED/BRD		Grids generally allow large animals to escape.
Other finfish		
Bycatch reduction device (BRD): Catch separators		A BRD is any modification designed principally to exclude fish bycatch from shrimp trawls. Catch separator designs include hard grids (*e.g.*, Nordmore grid) and soft mesh panels attached at an angle inside the trawl net as well as the Juvenile and Trash Excluder Device (JTED), which has a grid/mesh design partially covering the inside of the trawl net. Hard grids are generally seen as more effective than soft panels. Effectiveness of JTED unknown.
BRD: Active swimmer escape hatches		Designed for strong-swimming fish to actively escape (shrimp are more passive swimmers). Most are located in the codend (*e.g.*, fisheye and fishbox) although others can be in the body of the trawl (square mesh window, composite square mesh panel, radial escape section).
BRD: Square-mesh codend		Square mesh stays open under tow (unlike diamond mesh).
BRD assist		*E.g.*, the cone. Stimulates fish to swim forward through escape hatches like the fisheye, square mesh window or radial escape section.
Coverless trawl		Inclusion of increased mesh sizes in the upper wings and upper netting panel immediately behind the headrope crown, coupled with reduced headline height, encourages the escape of fish species such as haddock and whiting in and around the mouth of the trawl.
Rigging modification		Triangular/diamond-shaped cut in the top of the codend (*e.g.*, flapper), changes to ground chain settings, headline height reduction, a length of twine stretched between the otter boards to frighten fish, large mesh barrier across trawl mouth and large cuts in the top panel of the net ahead of the codend.
Semi-pelagic rigging		Avoid contact with seabed.
Trawl separator (Rhule trawl)		Reduces cod catch in haddock trawls by separating catch and releasing cod from the net.
Shellfish		

TED		TEDs generally allow large animals to escape (jellyfish). Downward facing TEDs may also allow benthic invertebrates to escape.
BRD *e.g.*, Nordmore grid		Effective for ~~jellyfish?~~ Crabs (Noell *et al. 2018)*
Rigging modification		Longer sweeps between the otter board and trawl can reduce invertebrate bycatch.
Semi-pelagic rigging		Avoid contact with seabed.
Other		
BRD		Seahorses, sea snakes in Australian prawn fisheries.
Gillnet		
Seabirds		Less research than for trawls.
Visual and acoustic alerts	-	Pingers may also reduce seabird bycatch (1 study in Lokkeborg 2008). High visibility panels (upper portion or checkerboard), dropped cork lines for shallow diving spp., attending nets (Wiedenfeld 2015).
Turtles		
Use lower profile nets	Primary	Reduces entanglement as the net is stiffer. Good for both demersal and drift nets.
Use of tie-down ropes	Negative	Creates slack in the net, increasing chances of entanglement (rather than gilling).
Set nets perpendicular to shore	-	Insufficient research. May reduce interactions with nesting females.
Use deterrents	-	Insufficient research. Pingers, shark silhouettes, lights or chemicals.
Deep setting	-	Insufficient research. Avoid upper water column (above 40m).
Sharks		
Unknown		
Marine mammals		
Pingers		Acoustic deterrence devices keep cetaceans away from nets. Effectiveness varies considerably depending on fishery and cetacean species: http://cetaceanbycatch.org/pingers_effectiveness.cfm. For pinnipeds they can have the opposite effect (Carretta and Barlow 2011).
Shellfish		
Weak buoy lines		
Mesh size		
Purse Seine		
Seabirds		
Not problematic		
Turtles		
Avoid turtles	Primary	Avoid encircling turtles. Restrict setting on FADs, logs and other debris.
Use of modified FAD designs	-	Insufficient research.
Sharks		
Avoid sharks	Primary	Avoid restrict setting on FADs, logs, other debris and whales. Avoid hotspots.
Shark repellants	-	For deployment on FADs. Insufficient research.

Use of modified FAD designs	-	Insufficient research
Marine mammals		
Backdown maneuver, Medina panel, deploy rescuers	Primary	
Avoid mammals		Restrict setting on mammals.
Other finfish		
Sorting grids	-	Insufficient research.
Avoid finfish		Restrict setting on FADs.
Shellfish		
Not problematic		
Pots and traps		
Turtles		
BRDs	Primary	*E.g.*, Diamondback terrapins in Floridian blue crab pot fishery (Butler and Heinrich 2005).
Marine mammals		
Weak lines	Primary	*E.g.*, northern right whales, NE lobster fishery.
Finfish, invertebrates		
BRDs	Primary	

Appendix 5 – Impact of fishing gear on the substrate

To assess fisheries for habitat impacts under the Seafood Watch® criteria, we developed a matrix to help determine the potential impacts that different fishing gear may have on various habitat types. The matrix was developed based on similar work done by the New England Fisheries Management Council (NEFMC 2010) and the Pacific Fisheries Management Council (PFMC 2005).

The NEFMC (2010) created a "Swept Area Seabed (SASI) model" that assessed habitat susceptibility and recovery information. Susceptibility and recovery were scored (0–3) based on information found in the scientific literature and supplemented with professional judgment when research results were deficient or inconsistent.

"Vulnerability was defined as the combination of how susceptible the feature is to a gear effect and how quickly it can recover following the fishing impact. **Susceptibility** was defined as the percentage change in functional value of a habitat component due to a gear effect, and **recovery** was defined as the time in years that would be required for the functional value of that unit of habitat to be restored (ASFMC 2010)."

The PFMC (2005) created a similar habitat sensitivity scale (0–3) that represents the relative sensitivity of different habitats to different gear impacts. The sensitivity of habitats from the PFMC (2005) was based on actual impacts reported in the scientific literature.

The relative impacts by gear and habitat type used for the Seafood Watch® matrix were based on the sum of sensitivity and recovery values from tables developed by the NEFMC (2010) (substrates) and the PFMC (2005) (biogenic). The NEFMC (2010) excluded deep-sea corals with extreme recovery times. The values for deep-sea corals in this matrix are the sum of the sensitivity and recovery scores from PFMC (2005). The following other biogenic habitats that were not included in the NEFMC (2010) data tables include: seagrass, sponge reefs (rather than individual sponges) and maerl beds. Due to the slow recovery and importance of these habitat types, they have been given the same value as coral and sponge habitats, all of which are listed as "biogenic."

Hall-Spencer and Moore (2000) examined the effects of fishing disturbance on maerl beds. Maerl beds are composed of a calcareous alga and form complex habitats with a high degree complexity. The associated species assemblages have high diversity (Hall-Spencer and Moore, 2000). Hall-Spencer and Moore (2000) showed that four years after an initial scallop-dredging disturbance had occurred, some fauna, such as the bivalve *Limaria hians,* had still not re-colonized the trawl tracks. Similarly, work by Sainsbury et al. (1998; in Kaiser et al. 2001) suggests that recovery rates may exceed fifteen years for sponge and coral habitats off the western coast of Australia.

Hydraulic clam dredges are rated as a high concern according to Seafood Watch ®. There are very few studies on the impact of this gear type, so we have relied on expert opinion (NEFMC 2010). Hydraulic clam dredges are used primarily in sand and granule-pebble substrates because they cannot be operated in mud or in rocky habitats (NEFMC 2010). This gear type is effective at pulverizing and/or removing solids and flattening out seafloor topography (NEFMC 2010). In addition, the habitats where this gear type is used are very susceptible to hydraulic dredges; recovery is moderate on average (NEFMC 2010). This leads Seafood Watch® to rate hydraulic dredges as "high concern." Hydraulic dredges do not operate on deep-sea coral or other biogenic habitats.

Neckles et al. (2005) found significant differences in eelgrass biomass between disturbed and reference sites up to seven years after dragging. The authors projected that it would require a mean of 10.6 years for eelgrass shoot density to recover in areas of intense dragging.

Demersal seines were not evaluated in the reports by Fuller et al. (2008), Chuenpagdee et al. (2003), NEFMC (2010) or PFMC (2005). Demersal seines include: Danish seines, Scottish fly-dragging seines and pair seines. These seines are similar to some bottom trawl gear in that they have a funnel shaped net with a groundrope. They are generally hauled by wires or ropes, and although they are lighter than some bottom trawl gear, they create habitat disturbance (Rose et al. 2000; Thrush et al. 1998; Valdemarason and Suuronen 2001). A review of trawling impacts by Jones (1992) grouped bottom trawling, dredges and Danish seines together as having similar impacts on the. However, studies have demonstrated Danish seines to have less impact on the substrate compared to bottom trawls (Gillet 2008). Therefore, in our matrix they are given an intermediate score as more damaging that bottom longlines and bottom gillnets, but less damaging than bottom trawls. Beam trawls also were not included in the reports but were considered to be similar to otter trawls.

The matrix developed from the sources referenced above is shown on the next page. For use in evaluating the Fisheries Criteria, these data have been summarized into categories (low impact, moderate, moderate-severe, severe, and very severe) to simplify use of the table.

Habitat impacts matrix: Relative impacts by gear and habitat type.

	Mud		Sand		Granule-pebble		Cobble		Boulder		Deep-sea corals **
	low	high	low	high	low	high	low	high	low	high	
Line, Vertical (BL/2)	0.5	0.5	0.6	0.5	0.8	0.8	1.0	0.9	1.0	1.0	1.3
Longline, Bottom****	0.7	0.7	0.9	0.8	1.4	1.3	1.6	1.5	1.7	1.7	2.0
Trap (lobster and deep-sea red crab)	1.3	1.3	1.2	1.2	1.8	1.7	2.0	1.9	2.1	2.1	1.3
Gillnet, Bottom****	1.3	1.3	1.5	1.4	2.0	1.9	2.2	2.1	2.3	2.3	3.0
Bottom Longline, Gillnet	1.0	1.0	1.2	1.1	1.7	1.6	1.9	1.8	2.0	2.0	2.5
Seine, Bottom (BL,G+TBO/2)	1.8	1.7	2.0	1.9	2.5	2.3	2.7	2.5	2.6	2.6	3.6
Trawl, Shrimp (BS+TBO/2)	2.2	2.1	2.5	2.3	3.0	2.6	3.0	2.8	3.0	2.9	4.1
Trawl, Bottom Otter	2.6	2.4	2.9	2.7	3.4	2.9	3.4	3.1	3.3	3.2	4.6
Dredge, New Bedford Scallop	2.6	2.4	3.0	2.8	3.5	3.0	3.5	3.2	3.3	3.2	5.1
Dredge, Hydraulic Clam	n/a***		4.4	4.0	4.9	4.5	n/a***				
Explosives/Cyanide	6	6	6	6	6	6	6	6	6	6	6

* Shrimp trawls tend to be lighter than bottom otter trawls for fish and do not need to touch the seabed to be effective.

** Most biogenic habitats (macroalgae, cerianthid anemones, polychaetes, sea pens, sponges, mussel and oyster beds) are incorporated into the scores for each substrate/gear combination in the table. NEFMC 2010 specifially excluded deep-sea corals. The numbers for deep-sea corals in this matrix are the sum of the sensitivity and (standardized) recovery scores in PFMC 2005. Other biogenic habitats that were not included in the NEFMC data tables include seagrass meadows, sponge reefs (rather than individual sponges) and maerl beds. Use the 'deep-sea corals' column for these habitats.

*** Scores not determined for hydraulic dredges in these habitats as the gear is assumed to not operate in them (NEFMC 2010).

**** NEFMC 2010 groups bottom longlines and gillnets as 'fixed gear' (not shown in table). These scores have been disaggregated here for substrate habitats only by adding 0.4 to the aggregated score for gillnets and subtracting 0.4 for longlines, base don the relative impacts shown in PFMC 2005 (i.e. that gillnets are generally more damaging than longlines).

The values above are the sum of sensitivity and recovery values in tables from Section 5.2 in Part 1 of (NEFMC 2010) (substrates) and Tables 4 and 5 in Appendix C, Part 2 of PFMC (2005) (biogenic). Gear types in black are from the Swept Area Seabed Impact (SASI) model used for the NEFMC EFH process (NEFMC 2010). Gear types in red are derived from those in black. Substrate types are self-explanatory except that mud includes clay-silt and muddy sand, and boulder includes rock. The energy regime is used here as a proxy for natural disturbance, with a cutoff between low and high stability at 60m depth. Most biogenic habitats (macroalgae, cerianthid anemones, polychaetes, sea pens, sponges, mussel and oyster beds) are incorporated into the scores for each substrate/gear combination in the table. NEFMC (2010) specifically excluded deep-sea corals with extreme recovery times. The numbers for deep-sea corals in this matrix are the sum of the sensitivity and (standardized) recovery scores from PFMC (2005). Other biogenic habitats that were not included in the NEFMC data tables include seagrass meadows, sponge reefs (rather than individual sponges) and maerl beds.

Appendix 6 – Gear modification table for bottom tending gears

Spatial protection

Reducing the footprint of fishing through spatial management can be one of the most effective ways to mitigate the ecological impact of fishing with habitat-damaging gears (Lindholm et al. 2001; Fujioka 2006). The relationship between gear impacts, the spatial footprint of fishing and fishing effort (*i.e.,* frequency of impact) is complex (Fujioka 2006) and cannot be quantified precisely in Seafood Watch® assessments. Nevertheless, the criteria acknowledge the benefits of conservative habitat protection efforts by adjusting the habitat score. Thresholds for adjusting the habitat score due to habitat protection from the gear-type used in the fishery (50% protected to qualify as "strong mitigation" and 20% protected to qualify as "moderate mitigation") are based on recommendations for spatial management found in the scientific literature as noted in Auster (2001). To minimize impacts on vulnerable species and sensitive habitats, Auster (2001) recommends employing the precautionary principle when a threshold level of 50% of the habitat management area is impacted by fishing, with a minimum of 20% of regions in representative assemblages and landscape features protected in MPAs.

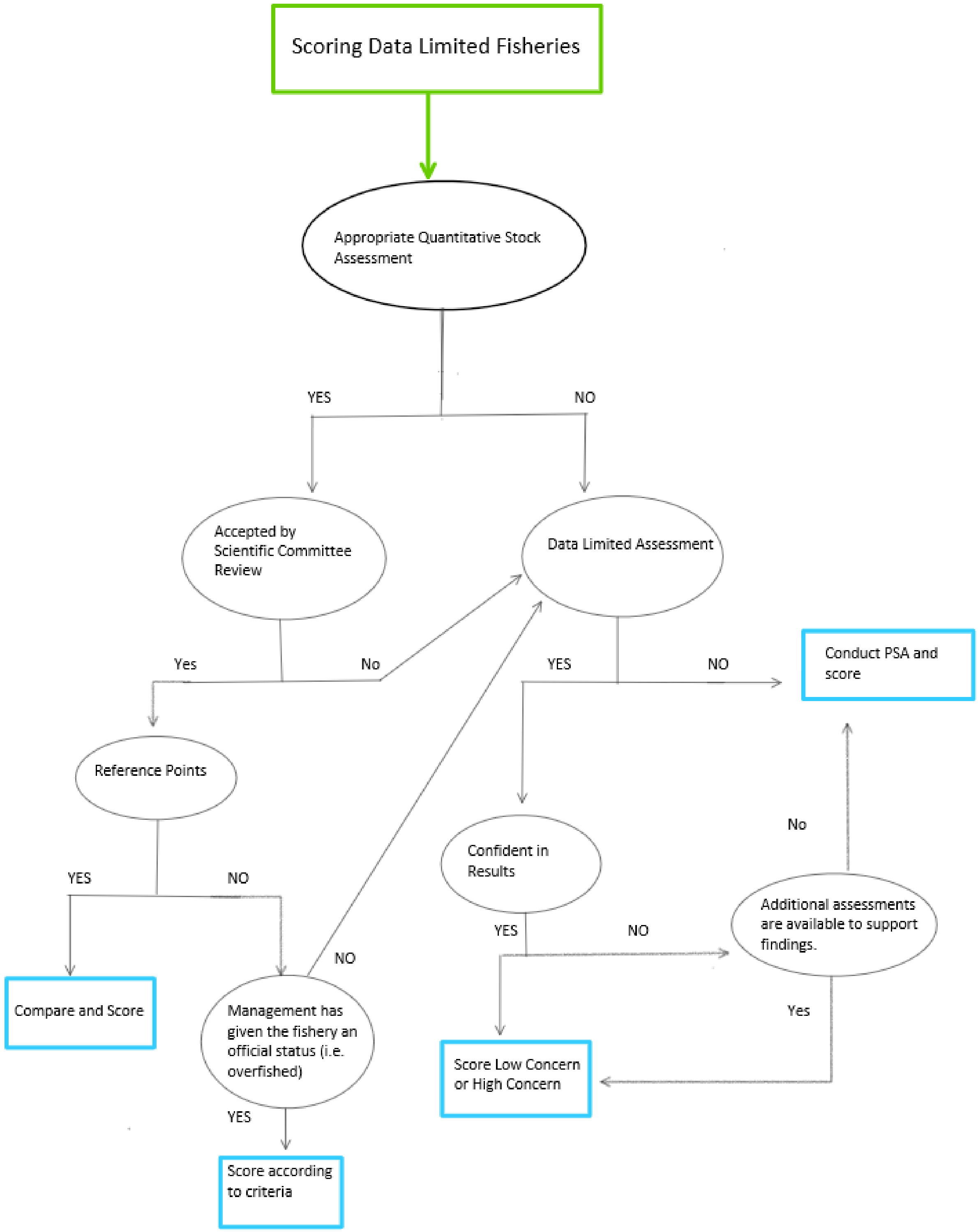
The table below gives examples of gear modifications that are believed to be moderately effective at reducing habitat impacts based on scientific studies. This table will be continually revised as new scientific studies become available. The main sources for the current table are He (2007) and Valdemarsen, Jorgensen et al. (2007).

Gear	Modification
Otter Trawls	Semi-pelagic trawl rigging (trawl doors, sweeps and bridles off the bottom, also includes modifications such as short bridles and sweeps—most commonly used for shrimp, nephrops and other species that are not herded by sand clouds and bridles due to poor swimming ability)
	Quasi-pelagic trawl rigging/sweepless trawls (trawl doors remain in contact with the seafloor, remaining gear largely off the bottom, *e.g.*, whiting in New England, flatfish in Alaska, red snapper in Australia)
	Lighter ground gear (*e.g.*, fewer bobbins)
	Use of rollers instead of rockhoppers
	Trawl door modifications such as high aspect (smaller footprint), cambered (generally for fuel efficiency) or soft doors (*e.g.*, self-spreading ground gear)

Appendix 7 – Data-limited assessment methods

This appendix offers guidance for scoring Criterion 1 with limited data for a stock.

Note: This guidance is provided for illustration purposes only. Expert input and case-by-case interpretation are necessary to ensure the assessment indicator is appropriate in the context of the specific fishery, and interpretation should take into account specific factors or changes in the fishery that may affect results (*e.g.*, demand-driven factors that affect size of the catch).



When considering how to proceed with limited data, first determine if a quantitative assessment exists and follow appropriate guidance once determined.

A quantitative assessment is available:

- And has been reviewed and accepted by a scientific committee where reference points have been determined, follow the standard scoring procedures.
- And has been reviewed and accepted by a scientific committee where reference points have not been determined, consider whether management has given the fishery an official status (i.e. overfished, not overfished).
    - If an official status has been determined by management score according to criteria.
    - If an official status has not been determined, proceed to following guidance as if there is no quantitative assessment available *(see guidance above)*.
- And was rejected by a scientific committee, proceed to following guidance as if there is no quantitative assessment available *(see guidance above).*

A quantitative assessment is not available:

- But a data limited assessment is available offering confident results, score accordingly as Low Concern to High Concern.
- But a data limited assessment is available; however, there is a high level of uncertainty that causes low confidence in the results of the assessment.
    - When another data limited assessment is available, consider confidence level in the results of the assessment, if confident, score accordingly from Low Concern to High Concern.
    - When no other data limited assessment is available, conduct a Productivity-Susceptibility Analysis (PSA) to determine species vulnerability to fishing pressure.

If a data limited assessment is NOT available, conduct a PSA to determine species vulnerability to fishing pressure.

Data limited stock assessments typically have high levels of uncertainty that can affect the confidence in the results. Confidence can be gained by evaluating how the data were collected (was sound scientific method used?), the type of data limited assessment, and the assumptions associated with the assessment approach. When assumptions have not been met and confidence in the results may be low it is important to consider whether there are other data-limited approaches that have been used for the same stock or species. Multiple assessments that show a similar result can increase confidence. It is also important to identify whether a scientifically accepted, peer-reviewed method was used. Further confidence can be gained through independent review of the data-limited assessment and results. Analysts should communicate with Seafood Watch staff to ensure accurate and consistent interpretation of data-limited assessment results.

Several published papers and online resources list potential data-limited methods ranging from very simple metrics to more data-moderate approaches and describe their use, their underlying assumptions, and their limitations. Analysts can refer to Dowling et al. 2019, and EDF's online tool, Framework for Integrated Stock and Habitat Evaluation's (FISHE) summary document as well as its primers on Length-Based Assessment Methods, Froese Length-Based Sustainability Indicators, Primer for Cope and Punt Length-Based Reference Point Method. The private data-limited decision supports FishPath; Dowling *et al.* 2016, while not currently available to SFW analysts, houses a comprehensive reference library of data-limited assessment methods. It may be made public while this Fisheries Standard version is in use.

Additional resources that provide overviews of data limited metrics are provided in the reference section at the end of this document.

Appendix 8 – Scoring salmon fisheries that include artificial production.

Evaluating Abundance of Salmon Stocks (Factor 1.1)

Salmon have very complex stock structures, with individual streams within a watershed often containing genetically distinct populations. This high level of genetic diversity is considered a key factor in adapting to a range of specific habitats and is believed to be crucial in enabling salmon stocks to continue to adapt in response to a changing environment, for example climate change.

Due to their different life history and behavioral characteristics, salmon are typically managed using different approaches to other marine finfish. Often there is only one set of reference points, typically an escapement or spawning goal, rather than the traditional abundance and fishing mortality-based reference points of marine finfish fisheries. When assessing salmon fisheries it is important to consider:

- the type of reference point being used
- the appropriateness of the reference point
- what is being measured against the reference point
- performance of the stock against the reference point

Spawning reference points and escapement reference points are the most common and refer to the number of fish reaching spawning grounds or migrating past a particular monitoring site respectively. Appropriate reference points for salmon should ensure long-term viability of the SMU before providing harvest opportunities. In some instances, a management agency may use upper and lower reference points; in these cases, the mid-point should be used as the reference when scoring sustainability of escapement/spawning abundance etc.

Salmon stocks are characterized by high levels of annual variability driven by a range of environmental and anthropogenic activities. To account for this high level of variability, Seafood Watch assesses escapement/spawning abundance, etc., over a 15-year period. Performance of the SMU compared to reference points should be considered for each year and then scored as directed in the scoring table for Factor 1.1 (for example, to score a “low concern” more than 70% of major SMUs encountered in the fishery are healthy and exceed management targets over 60% of the time).

Due to the complexity of salmon populations, it is highly likely that salmon fisheries will catch fish from different SMUs (with the exception of some fisheries, especially terminal/in-river, which can target specific SMUs). This can make assessment of salmon fisheries against environmental performance indicators very complex. In an attempt to manage this complexity and produce recommendations that are usable by businesses and consumers, Seafood Watch assessments should consider the performance of SMUs compared to relevant reference points for each species caught. Major SMUs (those which constitute 5% or more of the landings from a fishery) for each species are assessed together in Criterion 1; minor SMUs (those which constitute less than 5% of landings) are assessed together in Criterion 2. This approach accounts for the management systems which aim to reduce the catch of low abundance SMUs to the extent possible. When determining whether a particular SMU should be considered major or minor, analysts should use an average of catch composition data for the most recent 5 years (where available); when doing so it is important to consider recent changes in management that may have impacted catch composition to ensure the average is a reflection of the current situation. If recent data on catch composition are unavailable, historical data can be used however additional precaution should be used and an absence of up-to-date information should be considered when scoring management in Criterion 3. When there is no information on catch composition, salmon should be assessed at the species level as a stock of unknown abundance, i.e. a Productivity-Susceptibility Analysis should be used to score abundance.

In selective fisheries, some salmon species or SMUs may be released due to ETP status etc., potentially in good condition. In these cases, available post-release survival rates should be considered in evaluating released salmon. Where salmon are released and there is evidence of high post-release survival, these SMUs should be assessed in Criterion 2 as minor SMUs.

When evaluating the abundance of salmon SMUs, it is important to consider the composition of the SMU and how abundance of the SMU is monitored. Due to the wide variety and number of salmon populations, it is often not possible to monitor each one. In many cases, a selection of populations within an SMU are monitored and used as a proxy for the remaining populations. When this is the case, it is important to consider whether these proxies are appropriate. Analysts should seek evidence to support the use of these proxies and ensure confidence in the abundance estimates. Any evidence that proxies are inappropriate should be considered, and if significant uncertainty results from this evidence the score for abundance should be reduced.

If there is no stock assessment, or there are no abundance-based references points, it is possible to look for data-limited assessment methods to provide an indication of whether an SMU is considered abundant or depleted. Guidance on data-limited assessment methods and how to interpret the conclusions can be found in Appendix 7. In addition to the methods identified in Appendix 7, it is possible to consider trends in abundance to indicate the status of salmon SMUs. Many salmon SMUs, or their component stocks, have long time-series to enable us to consider abundance relative to historical averages. If trends are to be used to indicate the status of a particular SMU, long-term and short-term trends should be considered in the context of environmental fluctuations.

Evaluating vulnerability of Salmon to Fishing Activities (Factor 1.1)

The life history characteristics and behaviors of many salmon species result in a variety of factors that increase their vulnerability to fisheries that are not captured by typical Productivity-Susceptibility analyses. Seafood Watch has added two additional factors to be considered when assessing salmon species to account for these characteristics

Selectivity – A number of biological and behavioral characteristics can increase the susceptibility of a species to fishing activities. It is important to consider these characteristics, for example, migratory bottlenecks, spawning aggregation, site fidelity, unusual attraction to gear, sequential hermaphrodite, semelparity, segregation by sex, when determining the susceptibility of a species to a particular fishery. Management measures can be used to effectively mitigate for these characteristics, for example, spatial and temporal closures can mitigate against migratory bottlenecks and spawning aggregations. Where such management measures are in place these factors can be discounted. Where there is an absence of information for a population or fishery, a default score of high susceptibility should be awarded for salmon populations, as they typically have multiple characteristics and behaviors that lead to increased susceptibility.

Quality of Habitat – High quality habitat is key for the survival and high productivity of fish species. For salmon in particular, spawning habitat is particular critical and availability is a significant cause for concern in many populations. Unlike broadcast spawners in the open ocean where habitat is readily available, salmon are reliant on very specific conditions within rivers. Often these habitats have been lost or modified, or access to them is obstructed. To assess the productivity and vulnerability of a population, it is important to consider how much high-quality habitat is available to allow continued productivity. Where there is an absence of information on the quality and availability of habitat, a score of “moderate” productivity should be given as most salmon watersheds have experienced some level of disturbance or habitat loss.

Evaluating Management of Salmon Fisheries (Factor 3.1)

Alternative management strategies – Most management agencies assess salmon stock health and the impacts of fishing through escapement goals or MSY-based reference points. These management goals are often based on the performance of a group of populations, rather than single populations, due to the expense and time needed to define and track goals for many individual populations. Although these strategies may be successful in achieving management goals, including population recovery, in some cases the resolution of these methods may not be enough to ensure success. In these cases, alternative strategies that are not commonly implemented in current management may prove useful. Generally, tracking salmon escapement at the population-level greatly improves understanding of trends in abundance (including recovery) and impacts of fishing. This idea serves as the bases for an approach recently implemented in Norway salmon management. Conservation limits were defined for all known salmon populations in Norway based on biomass levels expected to reach carrying capacity, through use of model simulations (Forseth et al. 2013). Salmon returns are tracked annually using some assumptions, and exploitation rates are set to try to meet conservation limits in three of four consecutive years. This and other alternative strategies should be considered by managers where current strategies are failing to achieve conservation goals.

Recovery of stocks of concern – The management of salmon fisheries which interact with multiple SMUs can be complex, particularly when considering the challenges of minimizing the impact on low abundance SMUs and maximizing harvest opportunities on more abundant SMUs. When considering the effectiveness of management in promoting the recovery of stocks of concern (depleted or listed), it is important to consider whether rebuilding plans are in place. An effective rebuilding plan should have a timeframe not exceeding two generations, with highly effective rebuilding plans aiming for recovery within one generation. In some instances, hatchery supplementation is used as part of a rebuilding plan, particularly where individual stocks have become depleted to very low levels (and in some instances extirpated). Highly effective rebuilding strategies will seldom use hatchery supplementation to aid in recovery, and where they are used it is as a temporary conservation measure to preserve or restore wild diversity that has been threatened by human activities (including but not exclusive to fishing and hydroelectric dams). Required duration of this strategy of hatchery supplementation may be several salmon generations but should be no longer than necessary to establish a self-sustaining population.

Evaluating Impact on Habitats (Factor 4.1)

The scoring table in Factor 4.1 is based on a review of available literature describing the potential impacts of different fishing gear on aquatic habitats (which is summarized in Appendix 5). Most of these studies consider marine habitats and may not reflect the potential impacts of riverine fisheries. Where studies exist to demonstrate the impact of riverine fisheries, the results can be compared with those described in Appendix 5 and the fishery scored accordingly.

Ecosystem Based Management of Salmon Fisheries (Factor 4.3)

When considering ecosystem-based management, it is also important to consider habitat restoration efforts that may be taking place in the freshwater and brackish systems. In the past, hatcheries were intended to mitigate for lost habitat and harvest opportunity, due to dam construction, overharvest and habitat destruction. Management agencies may be involved in habitat restoration efforts to help improve the natural spawning habitat for wild salmon populations, increasing their likelihood for recovery. Habitat restoration should be considered as part of a holistic ecosystem-based management plan to help recover and maintain healthy wild salmon populations and reduce the reliance on hatchery production. Management agencies may be working independently or in collaboration with other local actors to ensure that there is a healthy ecosystem in which wild salmon populations can reproduce.

Evaluating Impact of Artificial Production on Wild Stocks (Factor 5.1)

Salmon from artificial production systems such as hatcheries can negatively impact wild salmon in a number of ways (Flagg et al. 2000, Naish et al 2008). One of the major concerns is the genetic impact from artificially produced fish spawning with wild fish, which may reduce genetic diversity, productivity and fitness of the population. To determine the impact of a specific artificial production system on individual populations and habitats, complex, lengthy and costly studies are required.

There are two main categories of artificial production systems used in the North Pacific. **Segregated** hatchery programs are typically used to increase the numbers of fish available for harvest. The aim is to establish salmon runs that can be targeted by tribal, commercial and/or recreational fisheries. Segregated programs use artificially produced fish, including in some cases non-local stocks, as broodstock. Segregated programs typically have a larger impact on wild fish but can be used effectively in cases where returning hatchery fish have minimal overlap, temporally or spatially, with wild fish. **Integrated** hatchery programs are typically used to conserve or recover populations, particularly where they are depleted or endangered. Because integrated programs are often designed to supplement natural-origin fish in a population, this can result in high levels of interaction between hatchery-origin and natural-origin fish. Therefore, it is important that hatchery-origin fish are genetically similar to natural-origin fish in a given population (achieved by increasing pNOB and reducing pHOS).

As scientific studies to demonstrate the effects of artificial production on wild salmon are often not available, Seafood Watch allows for use of a proxy to assess the risk associated with a particular fishery. The proxy includes different data depending on the availability. Where data are available, Seafood Watch will use assessments of pHOS and pNOB. The thresholds used in Table 5.1.2 were mainly adapted from the Hatchery Scientific Review Group (HSRG 2015). The HSRG is the independent scientific review panel of the Pacific Northwest Hatchery Reform Project which was established by US Congress in 2000. The principle behind the scoring system Seafood Watch uses is to ensure that the genetic diversity of wild stock is maintained (and any negative genetic effects from artificially produced fish are reduced). In general, the impacts of artificial production are decreased by reducing pHOS as much as possible, although in rare cases high pHOS is needed to re-establish extirpated populations. Hatchery programs with high pNOB help ensure that the genetic profile of hatchery-origin fish is as close to the natural-origin fish as possible. In evaluating pHOS and pNOB, analysts should calculate the arithmetic mean of the most recent 4 years available; if less than four years of estimates are available, or estimates are more than five years old, these estimates can be used but should be considered less informative. Estimates of pHOS and pNOB are typically calculated by management agencies on the population or hatchery program level. If pHOS estimates for an entire SMU are needed and unavailable, but relevant data are accessible, analysts can calculate pHOS across the SMU by dividing the estimated number of hatchery-origin spawners by the estimated total spawners (hatchery- and natural-origin) for the same populations. Similarly, pNOB across the SMU can be calculated by dividing all wild fish used as broodstock by total fish used as broodstock in all relevant hatchery programs.

Where pHOS and pNOB estimates are unavailable, Seafood Watch assesses the proportion of juvenile production that comes from artificial production relative to wild production (see table 5.1.2). When information on wild production is not available, Seafood Watch will evaluate the magnitude of hatchery-origin fish released or the percentage of hatchery fish in the harvest of the SMU (if known); scoring will be precautionary in these data limited situations. Additional factors that might be considered when evaluating data limited situations to determine impacts on wild fish include: whether relevant hatchery programs are integrated or segregated, whether there are selective fisheries or other management strategies in the local area (e.g., in-stream weirs or traps) to remove hatchery fish and reduce pHOS, the location of the hatchery, and the hatchery release site (adapted from the MSC Fisheries Standard v2.01).

Evaluating Artificial Production Management Systems (Factor 5.2)

Management Strategy and Implementation

The overarching aim of any artificial production management system at the local, regional, national, or international level should be to protect the diversity, abundance, productivity or genetic integrity of wild populations. There are known risks associated with artificial production; however, it is important to consider that there can be benefits to artificial production systems when managed effectively and that there can be a risk of extinction to wild stocks if hatcheries do not support them. When evaluating a management strategy for an artificial production program a number of key components must be considered. The following considerations are adapted primarily from the recommendations set forth by the HSRG for the Columbia River watershed (HSRG 2009, HSRG 2015) and by Kostow (2008). While the recommendations were initially developed for artificial production systems in the Columbia River system, the scientific rationale behind the recommendations is applicable to a wide range of artificial production programs and is the basis for what Seafood Watch considers an appropriate management strategy. Other management strategies and policies can be considered highly or moderately effective providing there is strong scientific rationale and/or evidence to demonstrate their effectiveness.

Seafood Watch considers the following to be key components of an appropriate management strategy for artificial production programs:

- Managers should adopt a system of designating populations based on their relative importance for maintaining or recovering the viability of an ESU, CU or SMU. Viability should be measured based on salmon population productivity and abundance and should also take into account spatial structure and diversity (McElhany 2000, HSRG 2015). The HSRG (2015) considered the following designations when making their recommendations**:**
    - Primary – populations must achieve high viability (i.e., high levels of natural-origin spawning abundance and productivity)

  - Contributing – populations must achieve at least medium viability
  - Stabilizing – populations where current levels of viability must be maintained.
- Clearly stated goals for natural-origin primary salmon populations. Often management goals are to release a certain number of juveniles; however, an effective strategy will set goals related to numbers of natural-origin spawners or contributions to fishery harvest.
  - Conservation goals should be expressed in terms of the biological significance of the population.
  - Harvest goals should be expressed in terms of stock contribution to specific fisheries.
  - Population goals should be compatible with goals of other stocks with which there are known interactions, or interactions are likely.
  - Goals should consider interactions between artificially produced salmon and wild salmon throughout their lifecycle, including freshwater rearing, marine growth phases, and migration and spawning.
- There should be a solid scientific foundation for artificial production programs based on a thorough assessment of associated benefits and risks.
- The purpose of the artificial production program should be clearly identified; is the primary purpose for conservation, harvest, or a combination of the two?
- Any scientific assumptions made during the formulation of the strategy should be clearly identified so that they can be evaluated as and when new information or scientific understanding becomes available.
- The broodstock strategy should be clearly identified. **Segregated** strategies have the intent of supplementing harvest using fish of hatchery-origin only, although the program may have been developed originally using wild fish from the same area. **Integrated** strategies aim to maintain the genetic diversity of the wild population and minimize any potential genetic impacts of domestication but may also have harvest goals associated.
- The size of the program should be appropriate to achieve, but not exceed, the population goals.
- Artificial production should be supported by a self-sustaining broodstock. For segregated programs this refers to artificially produced fish returning to the production site which are then selected for spawning. For integrated programs this refers to artificially produced fish returning to the production site and wild fish of the same species and stock returning to the same area. The use of out-of-basin spawners is not considered appropriate, unless there is a catastrophic spawning failure.
- Artificial production should be coordinated across a range of geographic scales, for example, watershed, regional, ocean basin.
- Artificial production facilities should be constructed and operated in compliance with environmental laws and regulations.
- Strategy aims to maximize the survival of artificially produced juveniles by implementing best practices. By doing this, conservation programs will accelerate the recovery of wild stocks, and harvest programs will minimize their impact on wild stocks as the numbers of juveniles released will be decreased.

- The management strategy, goals, and performance against these goals are reviewed on a regular basis. It is recommended that these reviews take place at intervals of no longer than 5 years.
- Research strategies should prioritize studies which will lead to potential solutions for known or expected problems such as long-term productivity of wild stocks where artificial production is taking place.
- There should be sufficient flexibility within a strategy to allow it to adapt to emerging data, research, and scientific understanding.
- Artificial production programs should be discontinued or modified when associated risks outweigh the potential benefits.
- Management of salmonid fisheries and artificial production systems may seek to take advantage of the temporal differences between the migrations of different salmon stocks.
- Measures to reduce interactions between artificially produced fish and wild fish, and interactions between all salmon and fisheries, can be considered as part of an appropriate management strategy. For example, selective fishing techniques that harvest hatchery fish with negligible impact on wild populations, or weirs to prevent hatchery fish reaching natural spawning areas.

A "highly effective" management strategy should aim to protect the diversity, abundance, productivity and genetic integrity of wild populations. Evidence should be used to demonstrate that management strategies and policies are effective in achieving these aims. The approaches listed above are expected to be effective and should be considered as part of a highly effective strategy; however, they may not be appropriate or successful in all situations, and other approaches may prove to be more effective.

A "moderately effective" management strategy should also aim to protect the diversity, abundance, productivity and genetic integrity of wild populations; however, we may expect that some of the concerns associated with artificial production are not addressed sufficiently, or there may be a lack of evidence to demonstrate that they are implemented effectively and are delivering the aims of the management strategy. In order to be considered "moderately effective" there must be an expectation that the strategies will be successful with plausible evidence provided to support such conclusions.

A management strategy would be considered "ineffective" if there is no management strategy in place, or if the strategy does not address concerns associated with artificial production, or if there is evidence that the strategy is not effectively implemented.

Monitoring and Research (Sub-factor 5.2.2)

Certain information is considered critical for monitoring the impact of artificial production and the effectiveness of management strategies. Based on the principle that "Hatchery fish should not be released unless the contribution of those fish to natural spawning escapement can and will be estimated with reasonable accuracy on an annual basis" (HSRG 2009), data should be collected on the contribution to specific fisheries from individual artificial production systems, and wild and hatchery spawner abundance of affected wild stocks should be estimated annually. Data collection and monitoring should focus on determining the impact and/or contribution of artificially produced fish to wild stocks and harvests. Impacts throughout the salmon lifecycle should be considered, including freshwater rearing, marine growth phases, migration, and spawning. Potential impacts include, but are not limited to, density dependence, competition for food and space, and genetic impacts.

Research priorities should focus on developing solutions for known and potential problems. For example, it has been established artificial production can successfully support increased harvest, however it remains uncertain whether artificial production can support natural production in the long term. Evidence suggests that some artificial production practices result in reduced fitness of released fish, which may have a negative impact on the wild stocks they are aimed to support (Araki et al. 2008, Grant 2012). Research should focus on determining the likely medium to long term impacts of current practices to enable management strategies to evolve and ensure effectiveness.

"Highly effective" monitoring and research will test the assumptions within a management strategy and demonstrate the impacts/effects of artificial production systems on associated wild populations. "Moderately effective" monitoring and research will include general themes which test the assumptions within a management strategy but impacts/effects of artificial production may not be fully known or understood. Failure to test any assumptions or monitor artificially produced fish within wild systems should be considered "ineffective" monitoring and research.

Credit can be given to research into novel hatchery techniques that seek to improve local adaptability of fish following release, minimizing the impact on wild populations and reducing the number of hatchery fish that need to be released in order to meet conservation or harvest goals.

Compliance and Enforcement (Sub-factor 5.2.3)

Sub-factor 5.2.3 considers the compliance with regulations pertaining to artificial production operations and the enforcement of these regulations. The existence of the regulations themselves should be considered as part of an effective management strategy in 5.2.1 or 5.2.4 depending on whether the regulations relate to salmon specific (e.g., the collection of broodstock) or ecosystem specific impacts (e.g., discharging of effluents). Analysts should score as "highly effective" if there is evidence that permits and regulations are complied with. Where there is an absence of evidence, a score of "moderately effective" is appropriate; with "ineffective" scored where there is evidence of non-compliance or known concerns with enforcement.

Ecosystem Based Management (Sub-factor 5.2.4)

Artificial production can have ecological impacts through facility operations (habitat impacts) and through the release of fish into the freshwater and marine ecosystems. Numerous studies and reviews have been compiled to describe best practices to reduce these impacts.

The following best practice examples have been identified by fishery/hatchery managers and review panels to minimize/mitigate impacts to the habitat:

- Facility design, construction and operations limit effects on the riparian corridor and are consistent with fluvial geomorphology principles (for instance, avoid bank erosion or undesired channel modification; CA HSRG 2012).
- Water withdrawals and in-stream water diversion structures for artificial production facility operation do not prevent access to natural spawning areas, affect spawning behavior of natural populations, or impact juvenile rearing environment. For instance, in-stream flows between diversion and discharge return points, as well as further flow impacts downstream are not significantly diminished (NOAA 2001; CA HSRG 2012).

- Screened water supplies and outfalls are provided to prevent wild fish from entering the hatchery or hatchery fish escaping to adjacent waters, and screened intake structures conform with accepted or required fish screen or other appropriate criteria that match screen size and approach and sweeping velocity to the target organism requiring protection (CA HSRG 2012; NOAA 1997; IHOT 1995).
- Effluents from artificial production facilities conform with accepted or required levels that do not detrimentally affect natural populations (CA HSRG 2012; WDOE 2010; NOAA 2001).
- Weir/trap operations used to collect hatchery broodstock do not prevent access to natural spawning areas, do not affect spawning behavior or success of wild fish, and do not result in significant stress, injury, or mortality in natural spawners (CA HSRG 2012; NOAA 2001).
- A record of compliance with applicable environmental laws designed to protect natural populations and habitats from potential adverse impacts of artificial production program operation (HSRG 2009).

Kostow (2008) provided a list of management measures that should be taken to minimize the ecological risks from artificial production. Analysts should use to the following guidelines to assess impacts from releasing artificially produced fish; more detail can be found in Kostow (2008).

1. Operate hatchery programs within an integrated management context
2. Eliminate hatchery programs when they do not provide a biological or social benefit
3. Reduce the number of hatchery fish that are released
4. Scale hatchery programs to fit carrying capacity of the freshwater ecosystem
5. Limit the total number of hatchery fish that are released at a regional scale
6. Only release juveniles that are actively smolting and will promptly out-migrate
7. Release smaller hatchery fish similar to the size of wild fish, provided they are smolting
8. Use acclimation ponds and volitional releases to reduce straying and revisualization
9. Locate large releases of hatchery fish away from important natural production areas so they can be harvested in terminal areas with low bycatch of wild salmon stocks
10. Time hatchery fish releases to minimize ecological risks
11. Restrict the number of hatchery adults allowed into natural production areas
12. Mark 100% of the hatchery fish and monitor the effects of hatchery programs

Based on the information provided, analysts should explicitly consider the following policies and procedures when evaluating the ecological impacts from artificial production.

Formal disease management policies and strategies are in place that are known to be effective (e.g., implemented and monitored).
Have hatchery polices and operational plans in place, implemented, and evaluated that are explicitly designed to minimize impacts on wild fish (e.g., prohibition on using non-local brood stocks, hatcheries are sited away from significant wild populations, straying is minimized, etc.).
Hatcheries operate to minimize any negative habitat impacts (e.g., water quality and quantity, access to spawning and rearing habitat, etc.).
Have management strategies in place to minimize freshwater ecological interactions between hatchery and wild fish (e.g., hatchery juveniles represent less than 5% of total, release times and locations minimize the likelihood of overlap or competition, fish ready to migrate rather than stay and rear).
Marine ecological interactions are highly likely to be minimal (e.g., release numbers represent <10% of total juveniles in the production and nearshore areas, or potential negative interactions have been explicitly evaluated and determined to be insignificant).
Artificial production is coordinated across watershed, regional, and international geographic scales to ensure carrying capacity of freshwater, estuarine, and marine ecosystems are not exceeded.

Appendix 9 – Document Revision History

During the 2019–2020 Standard Revision process, the following changes were made to the Seafood Watch standard for Salmon Fisheries.

Overall

- Changed title from "Standard for Salmonid fisheries" to "Standard for Salmon fisheries" and referred to "salmon" throughout
- Added table of key terms and definitions to preamble
- Added changes to Standard for Fisheries made during the 2019–2020 review to the Standard for Salmon Fisheries

Criterion 1

- Changed scoring requirements for Factor 1.1 such that appropriate reference points must be exceeded in at least 80% of the last 15 years to score "very low concern" (previously 70%), and at least 60% of the last 15 years to score "low concern" (previously 50%).
- Changed Factor 1.2 scoring table such that if fishing mortality relative to reference points is unknown or mortality-based reference points are not established, a fishery would be scored as "moderate concern."

Criterion 2

- Made no changes unique to the Salmon Standard (changes made to Criterion 1 and 2 in the Fisheries Standard were made here as well, if applicable).

Criterion 3

- Added guidance regarding how to score salmon fisheries that release salmon (including minor SMUs).

Criterion 4

- Changed captions for tables 4.1.1 and 4.1.2 captions to allow for assessment/mitigation of impacts in freshwater habitats from salmon fisheries that operate within freshwater areas.

Criterion 5X

- Added guidance regarding the timescale of assessing impacts of artificial production.
- Combined information previously presented in 5.1.3 into Table 5.1.2, to clarify the two approaches available to score factor 5.1, dependent on the available data.
- Within Table 5.1.2, "Impacts" column, slightly changed pHOS thresholds for minor/moderate to match recommendations from HSRG (2015).
- Added reference to "primary" populations (if available) for setting management goals for "highly effective" in 5.2.1.
- Added requirements to Table 5.2.4 for scoring the ecosystem-based management of artificial production, relating to the level of coordination with other groups in implementing artificial production plans.

Appendix 8

- Factor 1.1. Added guidance for determining minor vs. major SMUs. Guidance was added for scoring selective salmon fisheries that release certain species or SMUs.
- Factor 3.1. Added a new section of guidance for Evaluating Management of Salmon Fisheries; this section contains guidance related to “alternative management strategies” and “recovery of stocks of concern.”
- Factor 4.1. Added a new section of guidance for “Evaluating Impact on Habitats” regarding potential habitat impacts from freshwater fisheries.
- Factor 4.3. Added a new section of guidance for “Ecosystem Based Management of Salmon Fisheries” regarding consideration of habitat restoration efforts.
- Factor 5.1. Added guidance regarding evaluation methods for pHOS and pNOB, and methods for evaluating impacts of artificial production when pHOS and pNOB are not available.
- Factor 5.2. Added guidance regarding population designations, and the value of this strategy for recovering and maintaining viable salmon populations.

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