ISSN 1198-6727

Fisheries Centre Research Reports

2021 Volume 29 Number 3

Estimating the biomass of commercially exploited fisheries stocks left in the ocean

Institute for the Oceans and Fisheries,
The University of British Columbia, Canada

Please cite as:

Maria L.D. Palomares, Sydney Baxter, Nicolas Bailly, Elaine Chu, Brittany Derrick, Maria Frias-Donaghey, Simon-Luc Nöel, Emmalai Page, Rebecca Schijns, Jessika Woroniak, Luisa Abucay, Elizabeth David, Selina de Leo, Martin Nevado, Shelumiel Ortiz, Vina Angelica Parducho, Patricia S. Yap, Mathew Ansell, Lincoln Hood, Gabriel Vianna, Rachel White, Dirk Zeller and Daniel Pauly (2021). Estimating the biomass of commercially exploited fisheries stocks left in the ocean. Fisheries Centre Research Reports 29 (3): 74 pp.

ISSN 1198-6727

Institute for the Oceans and Fisheries

University of British Columbia,

2202 Main Mall,

Vancouver, BC, V6T 1Z4.

Estimating the biomass of commercially exploited fisheries stocks left in the ocean

Maria L.D. Palomares[1], Sydney Baxter[1], Nicolas Bailly[1], Elaine Chu[1], Brittany Derrick[1], Maria Frias-Donaghey[1], Simon-Luc Nöel[1], Emmalai Page[1], Rebecca Schijns[1], Jessika Woroniak[1], Luisa Abucay[2], Elizabeth David[2], Selina de Leon[2], Martin Nevado[2], Shelumiel Ortiz[2], Vina Angelica Parducho[2], Patricia S. Yap[2], Mathew Ansell[3], Lincoln Hood[3], Gabriel Vianna[3], Rachel White[3], Dirk Zeller[3] and Daniel Pauly[1]

[1] *Sea Around Us*, Institute for the Oceans and Fisheries,
University of British Columbia, Vancouver, Canada

[2] Quantitative Aquatics, Los Baños, Philippines

[3] *Sea Around Us* – Indian Ocean, School of Biological Sciences
University of Western Australia, Perth, Australia

A report prepared by the *Sea Around Us*
in partial fulfillment of the deliverables
covered in the Grant and Collaboration between
Quantitative Aquatics, the *Sea Around Us* and
the Minderoo Foundation
on 16 December 2020.

Table of Contents

FOREWORD

It is with great delight that I write the foreword for "Estimating the biomass of commercially exploited fisheries stocks left in the ocean." It is not often that I read a description of a methodology with rapt attention. But in this case, the vision and history that underpin the method render it a compelling read in addition to the method itself.

The authors start with the basic premise that we need to know how much fish is left in our oceans relative to what was there prior to commencement of industrial fishing in the 1950s. Moreover, we need to know this by population and by marine ecoregion. Is the reconstructed global catch of 100 million tonnes in 2018 a lot? Or is it a small remnant reflecting 70 years of industrial fishing? What populations have declined the least and the most, and where?

With great detail and transparency, the authors document how they generate estimates of "fish left" for over 2,500 populations of exploited species. The concept of "fish left" is powerful in that it is based on well-proven ecological theory. It is easily understood by non-specialists – the politicians who make decisions, the bureaucrats who advise them, and the broader community. "Fish left" is also a compelling metric: the thought of populations being reduced in numbers to less than half within a human lifetime as a result of our activities is challenging.

The vision and a long-road travelled with determination and data.

There are three major achievements that have made estimating "fish left" a reality.

1) An appropriate method based on catch maximum sustainable yield (CMSY) was developed to estimate trends in biomass. The CMSY journey began in 2013 with ongoing refinements of the method since. Importantly, the authors rigorously test the CMSY method across data-rich and data-poor populations and those that straddle complex geographies. That the method is flexible in terms of data inputs further expands its relevance to fisheries assessment.
2) FishBase and its cousin SeaLifeBase provide species-specific life history parameters such as growth and mortality that allow the CMSY method to be applied across a truly diverse range of taxa. Over 30 years in building, these online encyclopedias of ocean life are constantly improved as new research becomes available.
3) Reliable catch data are needed as an input to the CMSY models. The *Sea Around Us* took up this challenge 22 years ago. The project produces reconstructed catch data that more fully reflect the true scale of fisheries exploitation, an outcome now recognised by the FAO. Because the *Sea Around Us* catch data are spatially allocated, we have the resolution to determine the biomass trajectories of highly localised populations.

The standardised, systematic and transparent manner in which the team at *Sea Around Us* and their hundreds of global colleagues have built these three databases has created a highly valuable resource now and for future ocean management and conservation. Knowledge is power, the power to rebuild our marine life populations.

Professor Jessica Meeuwig,
University of Western Australia – Marine Futures Lab

EXECUTIVE SUMMARY

This report presents the key results of a multi-year activity of the *Sea Around Us* devoted to assessing the status of marine fisheries globally. This was accomplished by estimating, for the Exclusive Economic Zones (EEZ) of all maritime countries and the high seas, the fraction currently left in the sea of the exploited populations of fish and invertebrates that occurred before the onset of large-scale industrial fishing.

More precisely, the 'fraction left' is the current biomass (B) of a stock relative to its initial biomass (B_o), i.e., B/B_o. This fraction was estimated for multiple exploited populations (or 'stocks') by applying a versatile stock assessment method (CMSY++), whose main features are also described. Altogether, over 2,500 stocks of fish and marine invertebrates (mainly crustaceans such as lobsters and mollusks such as squids) were assessed in the EEZs of countries on five continents and the high seas. These assessments were based mainly on long catch time series (typically 1950 to 2018) but considered, wherever they were available, the results of earlier assessments made by national or international fisheries management bodies.

Thus, the evaluations of fisheries status presented herein are not defined by data scarcity; rather, we used all available data pertinent to the status of fisheries in all maritime countries to reduce the uncertainty inherent in all stock assessments. The detailed results of these stock assessments and their supporting data are available on the *Sea Around Us* website (www.seaaroundus.org).

These results will also be used by the Flourishing Ocean Initiative of the Minderoo Foundation, which kindly funded a large part of our catch reconstruction update to 2018 and the stock assessment work described herein.

The Challenge of Assessing Fish Stocks

There is currently no effective, easily comprehensible, single-issue index for fisheries that exists globally and ranks countries such that their fisheries performance can be reported and improvements tracked. None of several other initiatives/indices (e.g., Ocean Health Index, Environmental Performance Index, etc.) that include aspects of fisheries address fisheries globally. Also, these indices are generally incomplete in their spatial coverage, with only a few translating their multi-sector data (maritime shipping, tourism, marine conservation efforts, protected areas, pollution, fisheries, etc.) into global rankings. It is also unclear how effective these platforms have been in promoting changes in policy, given the ongoing decline in global fisheries. As such, there is no single measure of fisheries performance, in terms of how well a country maintains its fish resources, that can help inform and challenge governments on the international level needed to find solutions to this national and transnational problem.

Since the 1990s, there has been a growing recognition and acceptance that global marine fisheries, the major driver of impacts on marine populations (Pauly *et al.*, 2002), even in the face of climate change (Cheung *et al.*, 2009; Cheung *et al.*, 2010), are in crisis almost everywhere, mainly due to a huge build-up in fishing effort and a declining resource base (Watson *et al.*, 2013; Costello *et al.*, 2016). A declining resource base in fisheries terms implies that the biomass of exploited fish populations has declined substantially, usually to levels below that which fisheries science suggests as optimum for maximizing long term sustainable catches (Pauly and Froese 2020). However, while detailed estimations of the biomass of fished stocks ('stock assessments' in fisheries terminology) are available for some of the major fisheries target populations in many economically developed regions (e.g., the EU, Norway, the US, Canada or Australia), similar biomass assessments are generally lacking for developing countries, even for their most heavily fished species.

There are several reasons for this deficiency in availability of biomass trend estimates, notably:

1. a long-standing lack of critical technical expertise, only slowly alleviated through dedicated training workshops (Venema *et al.*, 1988; Palomares and Froese, 2017);
2. a frequently cited "lack of data"; and
3. until recently, a dearth of methods to generate at least preliminary biomass time series estimates with the limited data that are available in most regions of the world.

Issue (1) remains a real problem, particularly for the developing world which in recent decades has seen the most pressure on fish populations due to fishing (Alder and Sumaila, 2004; Atta-Mills *et al.*, 2004; Pauly and Zeller, 2016a). However, issues (2) and (3) have been increasingly mitigated over the last two decades by addressing the perceived "lack of data" through the comprehensive reconstructions of global marine fisheries catch data, and the development of straight-forward methods relying mainly on fisheries catch time series to estimate population biomass trends over time (Martell and Froese, 2013; ICES, 2014; Rosenberg *et al.*, 2014; ICES, 2015; Froese *et al.*, 2017).

Thus, this project was conceived to help in establishing an index or measure for the fish biomass currently left in the EEZs of the world's maritime countries as a contribution to the work of the Flourishing Oceans initiative of the Minderoo Foundation.

Reliable catch time series - the *Sea Around Us* catch reconstruction method

The catch of fisheries is their most important and most fundamental characteristic, no matter whether it is obtained on the deck of a mega-trawler in the frigid waters of the North Pacific, or in a canoe along an African coast, or by women and children collecting invertebrates for the family's next meal while 'reef gleaning' on islands in the Indian or Pacific Oceans. Thus, reliable information on current or past catches are the foundation for understanding fisheries (Pauly, 2013). Moreover, fisheries are globally integrated, not so much because fish move, as asserted by many, but rather because distant-water fishing fleets quickly move between fishing grounds and ocean basins.

Local, regional, and national fisheries studies can generally be conducted using local or national data sets, often including the data sets that the investigator(s) may have contributed to. Thus, the 'local' or situational knowledge of the investigators will ensure a high likelihood of knowing about possible issues or challenges with the datasets being used. However, such local 'context' or knowledge is lost in the fisheries catch data submitted annually to the Food and Agriculture Organization of the United Nations (FAO) by its member countries, and which the FAO, after some harmonization, disseminates as the world's capture statistics (Garibaldi, 2012). However, these fisheries statistics, even though they have been and continue to be used largely unchallenged (e.g., Costello *et al.*, 2012), suffer from numerous biases, of which the following may be the most important:

1. Several countries do not submit figures derived from the catch realized by their fisheries, but of the quantities they plan or anticipate to catch (see Watson and Pauly, 2001 for China; or FAO, 2018 for Myanmar);
2. The catch of artisanal (i.e., small-scale commercial) fisheries is often under-represented by the reporting agencies in both developed and developing countries (Pauly and Zeller, 2016a);
3. The catches of non-commercial subsistence and recreational fisheries are largely unreported, even though they can be considerable in various countries (see Kleisner *et al.*, 2015 for recreational fisheries; and Zeller *et al.*, 2015 for subsistence fisheries);
4. The discarding of fish, a common practice in certain industrial fisheries, especially trawling, although well covered in FAO publications (e.g., Kelleher, 2005) is explicitly excluded from consideration in their FAO fisheries statistics database, which therefore represent landings statistics, not catch statistics (Zeller *et al.*, 2018);
5. No attempt is made to account for illegally caught fish, which are generally not officially reported; and
6. Taxonomic resolution (i.e., identification of catch to species) is lost in the FAO reporting, which often requires detailed landings data to be aggregated to coarser groupings.

While item (1) often leads to catch overestimation, items 2-5 will lead to catches being underestimated. Item (6) obscures the catch trends of individual species, preventing assessments at the level of individual stocks on the basis of their catch data.

Over the last 20 years, the *Sea Around Us*, whose core mission is to research and communicate the impacts of fishing on the marine ecosystems of the world (Pauly, 2007), has collaborated with hundreds of colleagues throughout the world to complete 'catch reconstructions' (Zeller *et al.*, 2007; Zeller *et al.*, 2016) in all countries of the world. These catch reconstructions are based on the notion that the deficiencies in 1-6 can be overcome, or at least mitigated, by the systematic acquisition and analysis of secondary data (Zeller *et al.*, 2016). Such data may come from various sources, ranging from the local studies of fishing villages by anthropologists (e.g., Ota, 2006), or localized case studies of under-represented fishing sub-sectors (e.g., Wass, 1980), or seafood purchasing receipts by restaurants and hotels (e.g., Smith and Zeller, 2016), or Household Income and

Expenditure Surveys (e.g., Anon, 2014), to international databases on general food consumption (e.g., Khatibzadeh *et al.*, 2016).

The philosophy behind catch data reconstructions using secondary data rests on two conceptual pillars:

1. Fisheries are a social activity and thus never operate in a social vacuum. Therefore, they throw a 'shadow' on the society and economy in which they are embedded (Pauly, 1998). Thus, it is almost always possible to infer an approximate catch from some indirect measures of fishing activity, such as fuel use, employment, direct sales to restaurants and hotels, etc.; and
2. If a fishery operates somewhere, it generates a non-zero catch. Thus, if in the absence of detailed data on this catch, a government official decides not to enter an approximate figure for the catch (that may or may not be correct), the officially reported catch of that fishery will be precisely zero +/- 0 tonnes in the official national data reported to FAO. While this is a very precise estimate, it is guaranteed to be very wrong.

Thus, catch reconstructions involve replacing precise but erroneous estimates of zero catch by imprecise, but far more accurate estimates of the catch of the hitherto undocumented fisheries. The results we derived from the about 200 reconstruction studies that were performed for all maritime countries and their territories were presented in Pauly and Zeller (2016a; b). The title of Pauly and Zeller (2016a) "*Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining*" summarizes the situation that we find ourselves in: we catch far more than we thought, but we are increasingly in the process of losing these high catches, mainly due to overfishing.

One of the major points made in Pauly and Zeller (2016a) is that the strong decline observed in the reconstructed total catches since the mid-1990s is partly masked in the data reported by FAO due to what is now called the 'presentist bias' (Zeller and Pauly, 2018). This bias is the inadvertent by-product of efforts by countries to regularly improve their national data collection and reporting systems, which is a commendable endeavor. Unfortunately, such improvement efforts often overlook the need to also comprehensively correct historical data back to 1950 for any changes in new data being incorporated into data reporting systems. Hence the focus on the present at the expense of the past, which leads to the presentist bias. Thankfully, there are signs that the FAO has recognized the importance of this bias (see p. 8 in FAO 2018) and the utility of catch reconstructions and other retroactive data corrections (see p. 93, Box 5 in FAO 2018). The catch data assembled through our massive catch reconstruction effort over more than 20 years are publicly available through our website (www.seaaroundus.org) and cloud data servers that are optimized for the delivery of large datasets.

The datasets are very large because they present annual marine catch data from 1950 to 2018 for the 273 individual Exclusive Economic Zone (EEZ) entities of all maritime countries and territories of the world, as well as a global reconstruction and harmonization of the industrial tuna and large pelagic fisheries conducted also in High Seas waters under the auspices of several Regional Fisheries Management Organizations (Le Manach *et al.*, 2016; Coulter et al, 2019). These datasets are so large because they also present these data by fishing sector (industrial, artisanal, subsistence and recreational); by taxon (over 2000 species, genera, families or higher groups); by fishing country; by reporting status (reported or unreported catches); by type of catch (landed or discarded); by major fishing gear (trawls, purse seines, longlines, etc.); and by the end-use of the catch (direct human consumption, bait-use, fish meal etc.).

In addition to being more comprehensive and detailed than officially reported data, the reconstructed catch data of the *Sea Around Us* are spatially allocated to over 150,000 ice-free ½ degree latitude/longitude spatial cells in a manner that is both ecologically viable and politically appropriate. This was achieved by intersecting, in our allocations, the catch data with biological probability distributions of occurrence for each of the over 2000 taxa in the catch data sets (Palomares *et al.*, 2016) and permitting access to countries' Exclusive Economic Zone waters only to those fishing countries that are known to access these waters, either via fishing access agreements or observed access (Zeller *et al.*, 2016). This intersection between catch data, biological distributions and fishing access information is obtained through allocation algorithms that have been derived, improved and refined in successive iterations (see Lam *et al.*, 2016). Thus, the availability of the comprehensive *Sea Around Us* reconstructed catch data at biologically and politically relevant spatial resolutions that are much smaller than those of the global FAO landings (which are reported by 19 very large FAO statistical areas) allows us to analyze global fisheries impacts more meaningfully in space and time.

The catch-by-cell approach implemented by the *Sea Around Us* implies that it is very straightforward to present, evaluate and analyze data for a vast number of 'geographies.' Thus, we present catches not only by EEZs and High Seas areas, but also by the 66 Large Marine Ecosystems defined by NOAA (Sherman and Duda, 1999); by the 19 large and ecologically uninformative FAO Statistical Areas; by the areas covered by the 17 Regional Fisheries Management Organizations (Cullis-Suzuki and Pauly, 2016); and, most recently, by the Marine Ecoregions of the World (Spalding *et al.*, 2007).

From catch time series to biomass estimates

To derive biomass trends over time from the global reconstructed and spatially allocated catch data, we used the now well-established and documented data-limited Bayesian 'Catch Maximum Sustainable Yield' or 'Catch-MSY' method originally proposed by Martell and Froese (2013), which, however, tended to overestimate F/F_{MSY} and underestimates biomass. Froese *et al.* (2017) revised and operationalized this early approach, and continuously refined and improved it (see Froese *et al.* 2018, 2020). This yielded an essentially new method, labelled 'CMSY', whose early version has been independently evaluated in a FAO technical report (Rosenberg *et al.*, 2014), and described as "*… overall best performer …*" and especially "*… suitable for fisheries in developing countries …*" among the data-limited stock assessment methods that were evaluated. Other evaluations of the CMSY method indicated similar performance to other models (notably performing well in estimating the depletion parameter, see Zhou *et al.* 2017). There was, however, a dependence of parameter results and associated uncertainties on the prior for the biomass at the end of time series prior (Kell *et al.* 2020; Pons *et al.* 2020). Zhou *et al.* (2017) concludes that these methods should be viewed more as complementary rather than competitive, and that the variable data sets available for such analyses may fit one model better than the other. Note that since it was published, the CMSY method has been applied in 58 scientific publications (see Appendix A). We applied the most recent version of CMSY, called CMSY++ for the assessments reported herein, which largely overcomes the deficiencies of earlier versions. Also, we based our assessments on our reconstructed catch data, and the decisions on the application of this model to various stocks were informed by expert opinions, notably from Dr Rainer Froese.

Like the Maximum Sustainable Yield (MSY) concept from which it gets its name, the CMSY method is based on an approach formulated by Schaefer (1954; 1957) to mathematically describe and understand fish population dynamics. This approach, also known as 'surplus-production' modeling, assumes that a given ecosystem has, for any animal population, a specific carrying capacity (k, roughly similar to unfished biomass B_o), and that if this population is reduced through an external event (e.g., fishing), the population will tend to grow back toward its carrying capacity.

Such growth (i.e., the population growth rate, or dB/dt) is conceived as the product of two elements, one being the *intrinsic* population growth rate of the population (r), as determined by the attributes of the individuals in the population in question (individual growth, age at first maturity, natural mortality, fecundity, etc.), the other being the current abundance or biomass (B) of the population, i.e., its closeness to B_o (as expressed by the term $1\text{-}B/B_o$). Thus, the biomass of a very small population cannot grow by a large amount (i.e., dB/dt will be low), even if its *r* is relatively high, and neither will a population that is near carrying capacity because, in this case, $1\text{-}B/B_o$ is close to zero. In other words, the maximum population growth rate occurs at an intermediate abundance, i.e., $B_o/2$ (Pauly and Froese 2020). Note that the low values of dB/dt near carrying capacity are not caused by density dependence of adults, but of recruits (due to a 'hockey stick' stock-recruitment curve, Barrowman and Myers, 2000).

Thus, human extraction of biomass via a fishery can in principle maintain a fish population at any given biomass level by removing every year an amount of biomass equivalent to the natural growth of that population in that year. The CMSY fisheries stock assessment method is built on this conceptual framework (see Pauly and Froese 2020), and it essentially consists of tracing, for an exploited population with a time series of annual catch tonnage, multiple trajectories of its likely biomass, each defined by a pair or r-k values, and identifying the trajectories that remain viable while accommodating the catches taken from this population and a few other constraints (Froese *et al.*, 2017). Here, 'remaining viable' means a population that is not going extinct, while the constraints (or 'priors' in Bayesian terminology) that are to be accommodated are assumed biomass reductions caused by fishing, especially in the final year.

The range of *r* values within which this search is conducted can be taken from FishBase (www.fishbase.org) for finfishes and from SeaLifeBase (www.sealifebase.org) for invertebrates, which provide qualitative measures of *r*, i.e., resilience (as defined in Musick, 1999; and refined in Musick *et al.*, 2000). For most exploited fish species, FishBase also provides *r* priors from a range of biological parameters, especially natural mortality (*M*), the von Bertalanffy growth parameter *K*, generation time, maximum age, and fecundity, including results of *r* from previous stock assessments.

On the other hand, the range of carrying capacity (*k*, or B_o) that is appropriate to a given stock will be specific to it, with the catch itself providing a scale. Thus, the maximum of a catch time series can be used as the lower limit of the range of *k*, while some high multiple of this maximum can be used as upper estimate. The CMSY software contains a heuristic to generate appropriate *k* ranges.

Thus, in practice, the CMSY method amounts to producing a multitude of potential biomass trajectories given a catch time series, a wide range of pairs of intrinsic growth rate and carrying capacity (*r* and *k*) estimates, and broad constraints (or 'priors') on acceptable trajectories.

These broad constraints should express prior knowledge on (a) the approximate level (in %) to which carrying capacity was reduced at the start of the time series, here 1950, or the year when the fishery was opened, and (b) the level to which carrying capacity was reduced at the end of the time series (also in % of *k*). Such independent knowledge about the relative population depletion can be obtained from general knowledge about a given fishery ("good", "not as good as it used to be", "bad", "very bad") and translated into broad percentage or fractional ranges relative to carrying capacity (*k*). For example, for "good", one can assign $0.4\text{-}0.8 \cdot k$, meaning 40-80% of the unfished biomass level; while for "bad" one would assign $0.01\text{-}0.4 \cdot k$.

Finally, the version of the CMSY model to be used here also implements a Bayesian version of the full Schaefer surplus-production model (BSM), which can use pre-existing and independently derived time series of relative biomass, e.g., catch per unit of effort (CPUE) data from official stock assessments when available. This typically results in narrower estimates of the confidence intervals around the best estimates of *r* and *k* and along the biomass trajectory that they imply.

Updating the underlying reconstructed catch data to the 2018 FAO data year

The reconstructed catch data time series for all maritime countries of the world, as maintained and hosted by the *Sea Around Us*, were updated using the latest FAO data, covering the year 2018, as released by FAO in May 2020. A standardized year is required for all country datasets, as all countries need to be updated before the spatial allocation to EEZs can be undertaken. Catch data updating is a time-intensive process that requires dedicated staff that are carefully trained and closely supervised to ensure appropriate data decisions are being made at every step based on best available information. Data updates also needed to follow the core catch reconstruction approach for methodological consistency, yet adjust data from various sources, update details and data corrections to country-specific circumstances.

The method for catch reconstructions are detailed in Zeller *et al.* (2007, 2016) and in the various chapters of Pauly and Zeller (2016b). This makes automatic updating impossible for many countries. However, for cases that did not imply a large increase in taxonomic resolution, the replacement of a fishing sector by another, or similar massive changes, a semi-automatic routine was devised (Noël 2020) which considerably accelerated our carry-forward procedures. The *Sea Around Us* prepared a *Handbook*, i.e., Research Protocol (Derrick *et al*., 2019) to capture in one single document, and systematize for incoming research staff, the methods used for catch reconstructions. Derrick *et al*. (2020a, 2020b) provide details by country and territory on the processes followed in updating the reconstructed catches by EEZ, including a description of the semi-automatic carry forward of Noël (2020).

Marine Ecoregions vs EEZs

The EEZs that countries can claim since the UNCLOS was concluded in 1982 extend a maximum of 200 nautical miles from the coast of maritime countries and their territories. Over 90% of the world's marine fisheries catch originates from EEZs. In some cases, e.g., around isolated islands, the inshore fauna belongs to a distinct ecosystem, and hence their exploited fish populations can be treated as distinct 'stocks.' However, in the majority of cases, and especially for large countries (e.g., the USA, Australia or Russia), the EEZs along their coasts encompass a range of very different ecosystems. For example, the US East Coast EEZ ranges from high latitude temperate systems in New England (e.g., Gulf of Maine) to a (sub-)tropical coral reef ecosystem in southern Florida. Therefore, in order to better address ecosystem issues in fisheries data and assessments, a more nuanced spatial system of MEs is offered by the *Sea Around Us* in addition to EEZs and Large Marine Ecosystems (LMEs; see Pauly *et al*. 2008).

The Marine Ecoregions of the World (often referred to as MEOWs, but here labelled MEs) are biogeographic entities along the world's shelves and coasts, as defined by Spalding *et al*. (2007) as part of a joint WWF/Nature Conservancy project. MEs, which have clearly defined definitions boundaries and are generally smaller than LMEs, are used to represent and spatially group ecological patterns of species and communities in the oceans and to serve as a tool for conservation planning worldwide. The presently available ME system focuses on coast and shelf areas and does not consider open-ocean pelagic or deep benthic environments (see Figure 1).

Using GIS shapefiles of MEs as part of our spatial data system ensures that the stock assessments we performed for all maritime countries in the world are applied at appropriate ecosystem scales. Internal consistency in our global spatial data allocations is ensured in two steps: (1) we slightly modified some ME boundaries to correspond to existing EEZ boundaries; and (2) we assigned the 232 MEs of Spalding *et al.* (2007) to our 273 EEZs (and parts thereof) as a function of the MEs' overlap with the EEZs (see Appendix D). Thus, the ME boundaries as presented and used on the *Sea Around Us* website may differ slightly from the ME shapefiles available from the WWF.

An example may be provided for MEs' overlap with the EEZs: Mexico has two separate EEZ components, one in the Atlantic, the other in the Pacific. On the Mexico (Atlantic) EEZ page, the *Sea Around Us* website lists the Southern Gulf of Mexico and Western Caribbean MEs as overlapping extensively with the Mexican Atlantic EEZ. However, a third ME (Northern Gulf of Mexico) also overlaps with Mexico's EEZ, though this involves only 14% of Mexico's Atlantic EEZ surface. For such cases, the *Sea Around Us* has set a minimum percentage coverage requirement of 20% of a given EEZ in order for a partially overlapping ME to be included. Hence, in the present example, the boundary for the Northern Gulf of Mexico ME was slightly modified to exclude Mexican EEZ waters. Note also that some MEs will be accessible from two or more countries. For example, the ME called Chiapas-Nicaragua, which extends from Southern Mexico (Pacific) to the boundary of Nicaragua and Costa Rica, will also be listed in the EEZs of Guatemala (Pacific), El Salvador, and Nicaragua (Pacific).

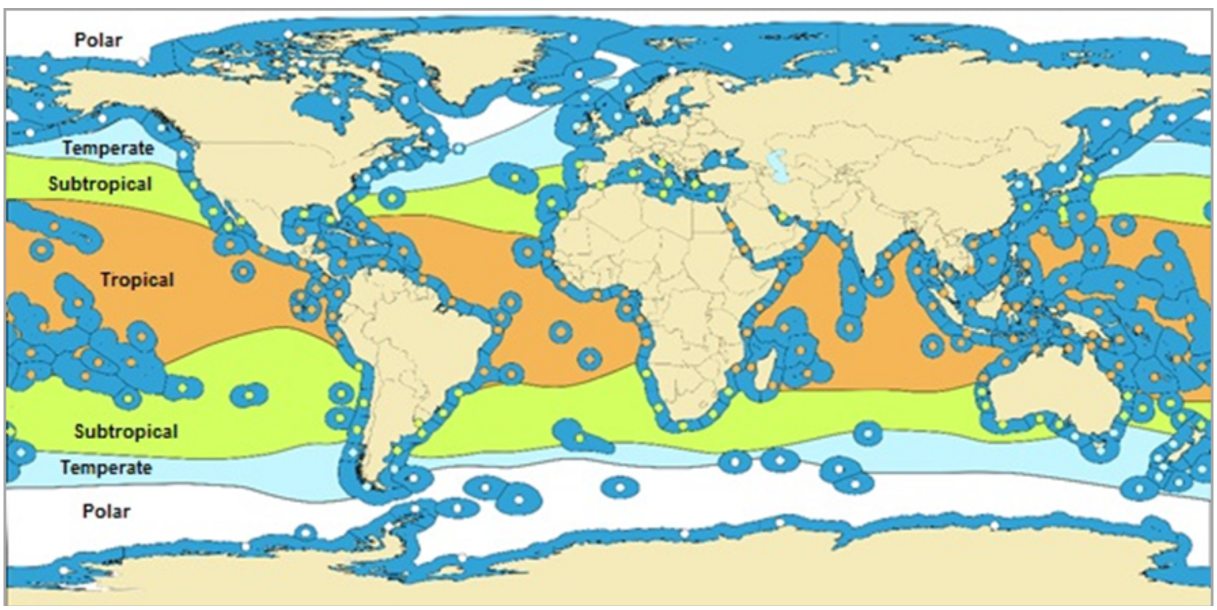

Figure 1. The global system of Marine Ecoregions (ME in dark blue, Spalding *et al.*, 2007) overlaid over climatic zones of the world (Anonymous, 1991). Centroid color in each ME indicates the climatic zone to which each ME was assigned. Adapted from Palomares *et al.* (2020).

Stock assessments[1]

Selection of viable catch time series for CMSY analysis

The *Sea Around Us* reconstructed catch data for 1950-2018, disaggregated to species level, account for the catch of about 838 species, representing 59% of the global catch of 6.2 million tonnes. From this data pool, we identified species-level[2] catch time series for CMSY assessment at the ME-level using the following criteria (Figure 2):

1) With total catches consisting <20% of discarded catch, as discard data are often more poorly documented over time than landed catch and therefore result in uninformative time series;
2) With catch time series following desirable conditions for CMSY analysis, that is:
    a) With continuous time series of >=20 years;
    b) With total accumulated catch for the whole time series >100 t;
    c) Without a stretch of very low catches at the beginning of the time series that might be attributed to:
        i) Catches generated only by subsistence and/or recreational fishing, e.g., prior to establishment of a commercial fishery;
        ii) Catches extrapolated backward towards an assumed start of fishery, e.g., in 1950;
        iii) Reconstruction was based on insufficient data sources, e.g., with low catch uncertainty score;
    d) Without spikes in catch towards the last five years that might be attributed to:
        i) Reconstructed forward-carry errors, e.g., due to a misapplication of the semi-automatic routine for updating catch time-series data; or
        ii) FAO baseline data error (a rare occurrence, but which may occur when the original FAO reported data contains an error); and
3) With catch cumulatively accounting for the top 90% of the total catch within each ME for the whole time series.

This process identified just over 1,300 ME-level stocks[3] with catch time series viable for CMSY assessment and is described in Palomares *et al.* (2018). These ME-level stocks were then assigned to EEZs overlapping with those MEs (see Appendix D). However, a large percentage of these ME-level stocks were wide-ranging and straddling, and sometimes did not represent the highest catches in an EEZ. Thus, there was a need to review the catch composition of EEZs and consider taxa[4] with large contributions to the catch that were not identified in the process above. Two more selection rounds were performed to identify taxa by EEZ that could be viable for CMSY assessment, viz:

4) Review stocks rejected due to Criterion 2:
    a) For stocks rejected due to Criterion 2a and where the catch time series were broken by only ≤5-year gaps, the gaps were filled by interpolating missing catches, and the stock was then accepted as CMSY-viable. Note that time series where several of these gaps were present were again rejected;
    b) Stocks rejected due to Criterion 2c were accepted if the time series could be truncated to start at a year in which the catch trend exhibited random behavior[5] and which leaves at least 20 years of continuous time series. This reduces the uncertainty of the remaining time series and renders the time series viable for CMSY analysis;

[1] This section was prepared by Maria L.D. Palomares, Vina Angelica Parducho, Luisa Abucay, Selina de Leon, and Martin Nevado of Quantitative Aquatics, Los Baños, Philippines.
[2] This is catch identified to the species level. Note that more than half of the taxa with catch data in the *Sea Around Us* are aggregated species groups, i.e., genus, family, order, class, phylum, and the "not elsewhere identified" (nei) groups.
[3] Here we define ME-level stocks as species with catch data for a given ME (non-straddling) or a group of MEs or FAO/RFMO areas or oceans (straddling).
[4] Here the term "taxa" refers to all taxonomic groups, including "nei".
[5] As opposed to a straight line that indicates a forward carry assumption.

c) Stocks rejected due to Criterion 2d were submitted for reconstruction process review to determine the source of instability in the last 5 years of the time series. If the trend of the last 5 years follows the underlying FAO data, then the dataset was accepted, albeit with the caveat that published evidence of the cause of the trend was required. In cases where such evidence could not be found, the dataset was excluded from the analysis and circled back to the reconstruction process for further investigation.

5) Review EEZs with the most pronounced bias towards straddling species[6] or with hundreds of exploited species (e.g., in MEs with tropical coral reefs, as in Southeast Asia). Stocks passing Criterion 2 and rejected due to Criterion 3, but with catches >100 t reported for that EEZ were accepted.

This process added about 1,700 stocks, making a dataset of about 3,000 ME-level stocks for analysis. For some EEZs, this process failed to identify additional species for analysis and as such the ratio between straddling and demersal species remained higher than the threshold 60:40 ratio.[7] For some island EEZs, this improved the straddling/demersal ratio to at least 70:30.

Selection of relative biomass time series to inform CMSY analysis

As part of the CMSY assessments, a series of literature searches were completed that enabled the assembly of a wide variety of supplementary data into a 'prior database' which is now included in the FishBase infrastructure.[8] These priors include: a) independent biomass or relative biomass/abundance data from traditional stock assessments; b) fisheries independent survey data; and c) catch per unit of effort data. Publicly available data and material, or materials that are shared via our global network of colleagues and contacts were prioritized. This includes the RAM Legacy Stock Assessment Database (Ricard *et al.*, 2012) as well as assessments by national (e.g., Australia, Canada, Japan, New Zealand, USA) and international management organizations (e.g., RFMOs such as the ICCAT, IOTC and WCPFC[9]).

The first round of literature searches was used to identify the official fisheries governing body of stocks in EEZs overlapping with one or several MEs, and, if available, the most recent assessment published for the stock by the governing body.[10] Reference points, catch data used in the assessment, and the relative biomass time series trend resulting from assessment models were extracted and encoded into a database (see discussion of the CMSY database below). The choice of the relative biomass time series used in the CMSY analyses followed the criteria below:

- The EEZ where most of a stock is caught best represents the stock in that ME and is the first choice for the source of relative biomass;
- Where such dominance is unclear, and if there are several official assessments available for a stock in a given ME, the relative biomass from the most recent assessment was used;
- Where there was more than one official assessment available for a stock in an ME for the most recent year, the average relative biomass trend was obtained using the harmonization process described in Winker and Sherley (2019);

---

[6] For instance, EEZs of island ecosystems (e.g., in the South Pacific), where species-level catches consisted mostly of straddling stocks, and non-straddling species were reported at genus- or family-level catches only. In such cases, we opted to use only species-level catches for analysis, mainly because relative biomass priors are difficult to obtain for higher level taxa.

[7] The balance between straddling and demersal species analyzed for each EEZ will improve with proper disaggregation of catch data to species level over time.

[8] Available in the FishBase "Species summary" page under the "Estimates based on models" section.

[9] Figure 9 for RFMO definitions.

[10] These assessments are mostly available as 'grey literature' (e.g., technical reports) or as online publications that were downloaded as PDF files.

- Catch per unit of effort and total biomass are the most informative relative biomass types (Froese *et al.*, 2020) and are used where available; other relative biomass types used by order of importance are: standing stock biomass, spawning stock biomass, and ‘abundance’ estimates.

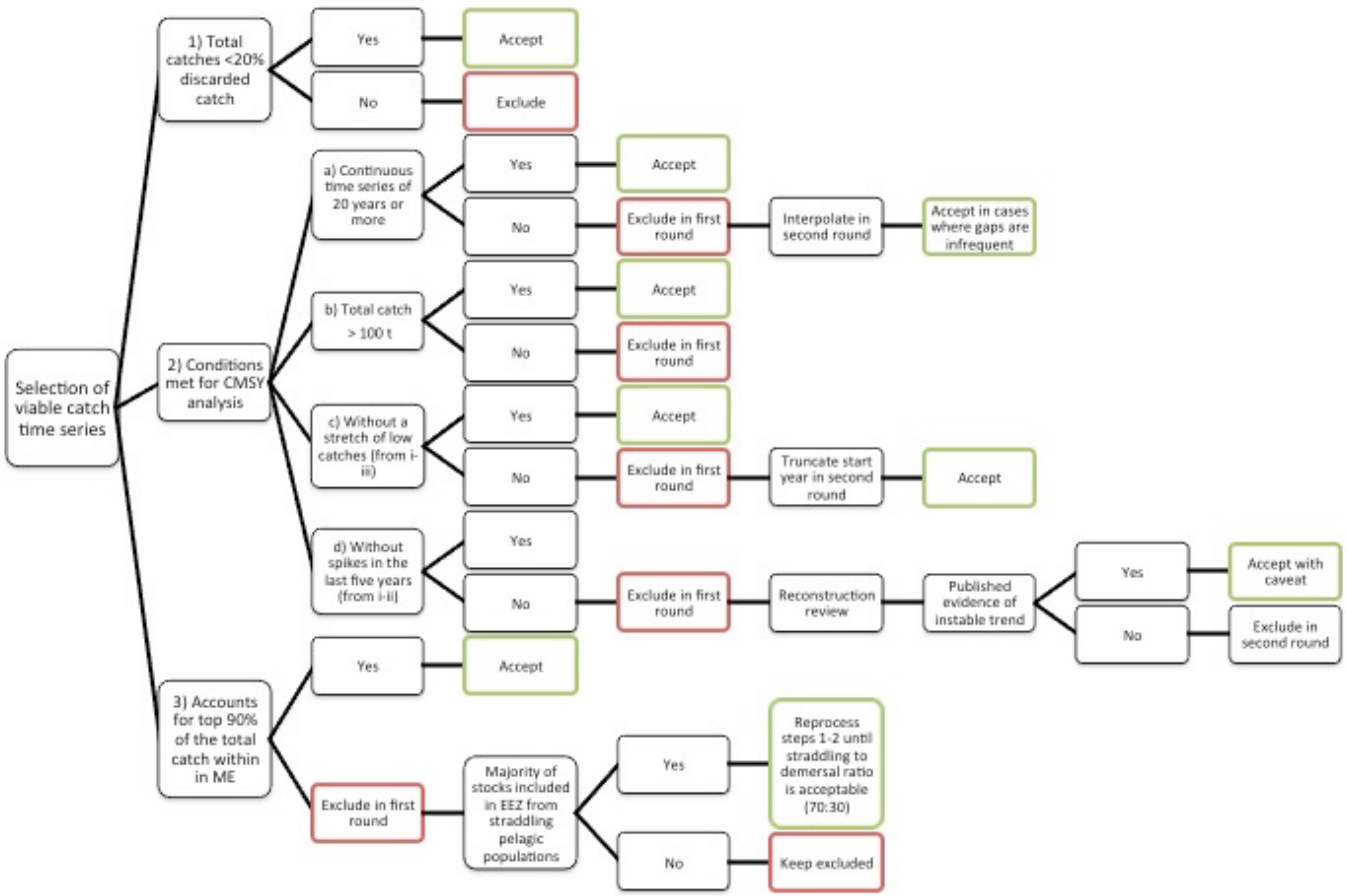

Figure 2. Flowchart for the three rounds of selecting populations with viable catch time series for CMSY analysis. Green boxes indicate stocks with time series that met the criteria and red boxes indicate stocks with time series that were excluded from CMSY analysis.

The second round of literature searches identified primary literature (e.g., scientific journals) that published any type of relative biomass information on exploited stocks. Primary literature accessed through the UBC Library, Google Scholar, Web of Science, FishSource, and CORE used the following search terms:

- Species name OR common name OR higher taxa name;
- ME OR EEZ OR RFMO OR country OR straddling area;
- Any combination of "fisheries stock assessment", "stock status", "fisheries management advice", "CPUE", "standing stock biomass", "spawning stock biomass", "relative abundance" "stock assessment", "biological reference points", "BMSY", "FMSY", "fishing effort", "biomass", "abundance."

Table 1. Prior ranges for parameter ***r***, based on classification of resilience after Froese *et al.* (2017).

Resilience	prior *r* range
High	0.6 – 1.5
Medium	0.2 – 0.8
Low	0.05 – 0.5
Very low	0.015 – 0.1

In addition, Google Scholar alerts were set up for these terms for any new published stock assessments or relative biomass information that keeps the relative biomass database updated with the most recent assessments available for any given stock.

Selection of priors to inform CMSY analysis

The bulk of estimates for resilience and intrinsic rate of population growth (*r*), were extracted from FishBase (www.fishbase.org) for finfishes and from SeaLifeBase (www.sealifebase.org) for invertebrates. In cases where the *r* range from stock assessments was missing, but where resilience was available, resilience or the *r* range were assumed following Froese *et al.* (2017; see Table 1). In cases where neither of these priors were available, resilience was inferred from vulnerability (the inverse of resilience) and the preferred temperature of the species (both available in FishBase and SeaLifeBase). That is:

- Species with high vulnerability and preferring colder temperatures are assumed to be in the low resilience group;
- Species with low vulnerability and preferring colder temperatures (<15 °C) are assumed to be in the medium resilience group;
- Species with low vulnerability and preferring high temperatures (>15 °C) are assumed to be in the high resilience group.

Table 2. Independent knowledge on the reduction of biomass by fishing or from carrying capacity following Froese *et al.* (2017). Prior ranges for parameter ***r*** based on classification of resilience following Froese *et al.* (2017).

Depletion level	prior *r* range
Very strong depletion	0.01 – 0.2
Strong depletion	0.01 – 0.4
Medium depletion	0.2 – 0.6
Low depletion	0.4 – 0.8
Very low depletion or nearly unexploited	0.75 – 1.0

Independent prior knowledge[11] on the reduction of biomass by fishing from carrying capacity at the start, intermediate, or end of the time series was translated into broad percentage or fractional ranges according to Froese *et al.* (2017; see Table 2). Where a rough estimate of *B/k* was available in the literature, a confidence interval of +/-0.2 was used. This corresponds to a fractional range of 0.4, e.g., 0.2 to 0.6 for terms equivalent to medium depletion (see Table 2).

[11] This knowledge was found in the form of quotes in the literature and documented in the 'prior database'.

In cases where the species were listed under the IUCN Red List of Threatened Species, the IUCN categories were translated into fractional ranges representing levels of biomass that are related to resilience levels (in Table 1) presented in Table 3.

Table 3. Correspondence of the IUCN Red List Categories to prior relative biomass (B/k) ranges.

IUCN Category	prior *r* range
Critically Endangered	0.01 – 0.1
Endangered	0.01 – 0.2
Vulnerable	0.01 – 0.4
Near threatened	0.1– 0.4
Least concern	0.6 – 1.0

Some official assessments available from FAO stock assessment reports lacked numerical reference points. In such cases, the FAO qualitative assessments were translated into B/k ranges by assuming B_{MSY} to be 50% of unfished biomass (B_o), assuming $B_o \approx k$, unless otherwise stated in the FAO assessment. Table 4 presents these ranges.

Table 4. Correspondence of FAO and *Sea Around Us* terms used to assess the status of exploited fish stocks. B_{MSY} is assumed to be 50% of unfished biomass (B_o), assuming $B_o \approx k$, unless otherwise stated.

FAO assessment	*Sea Around Us* terminology	prior *r* range
Not fully exploited	$B \geq B_{MSY}$ (Healthy)	0.50 – 1.00
Fully exploited	$0.8*B_{MSY} \leq B < 1.0*B_{MSY}$ (Slightly overfished)	0.40 – 0.50
Fully exploited	$0.5*B_{MSY} \leq B < 0.8*B_{MSY}$ (Overfished)	0.25 – 0.40
Overexploited	$0.2*B_{MSY} \leq B < 0.5*B_{MSY}$ (Grossly overfished)	0.01 – 0.25
Overexploited	$B < 0.1*k$ or $B < 0.2*B_{MSY}$ (Collapsed)	0.01 – 0.10

Where length-frequency data collected from the commercial fishery (preferably raised to the catch) was available, the exploited biomass relative to unexploited biomass (B/B_o) was estimated using the length-based Bayesian biomass estimator (LBB). This model applies asymptotic length (L_{inf}), length at first capture (L_c), relative natural mortality (M/K) and relative fishing mortality (F/M) from the length-frequency data. Such LBB data were most important in providing start year and/or end year priors where available.

Applying ME-based CMSY analyses to EEZs

Identifying ME-level stocks included in an EEZ was based on two criteria, viz.: 1) the extent of overlap of the ME with the EEZ (see Appendix D) should be 20-100%[12]; and 2) the catch of the stock in the EEZ should be >= 100 t. The first criterion was applied to ME-level stocks, and the second criterion refined the list of stocks obtained to create the EEZ-level stocks list. All CMSY results for these stocks were then applied to the resulting database of stock reference points for that EEZ. This process used about 3,000 ME-level CMSY stock assessments distributed to over 270 EEZs.

The resulting list of EEZ-level stock assessments were then submitted for review by country experts knowledgeable in the history and status of their countries' stocks. Results from the CMSY analyses (catch and B/k graphs and sources of priors when available) for each EEZ were prepared in a document with specific questions to the experts as those listed in Table 5. Experts were requested to provide additional CMSY priors data if these were lacking.[13]

A total of 68 country experts were contacted (see Appendix E), with about half of them agreeing to perform reviews. This process resulted in 1,642 ME-level stocks (more than half of the over 2,500 stock assessments) provided with at least a source and value for the end biomass prior or at most the source and biomass time series

[12] Where the EEZ/ME overlaps <20%, the EEZ was excluded from that ME.
[13] Because they were not available via the worldwide web and/or they originated from recent studies or pending publications.

resulting from an official assessment (see Table 6). Of these, 42% are based on official assessments (with the highest data reliability score of 4); about 35% are based on relative biomass time series (CPUE or spawning stock biomass; data reliability score of 3); and 23% are based on priors provided by experts (B/k estimates at the end of the time series; data reliability score of 2). The 33 experts who agreed to review their countries' stocks provided priors for half of these ME-level stocks and improved the reliability of over 20% of these assessments. Thus, the experts agreed with 80% of the CMSY assessments.

Once the review results were integrated into the EEZ-level stock assessments, the average B/B_o for all stocks included per EEZ was calculated. This value and the material that went into its calculation will be made available in the *Sea Around Us* website.

To demonstrate the use of official assessments as priors in CMSY assessments with Bayesian Schaefer Model results, a sample of 20 non-straddling and straddling stocks are presented in Table 7. These show that, on average, the CMSY assessments are optimistic by about 23% if B/B_o is used for comparison, by about 8% if B/B_{MSY} is compared and by about 3% if F/F_{MSY} is compared. Note that the greater disparity of B/B_o results is due to the fact that the B/B_o estimates from official assessments might have been calculated using varying (and thus maybe not comparable) assessment models (see Sharma *et al.* 2021).

Table 5. Example of questions submitted to experts to establish priors for CMSY analysis.

Prior	**Question to the experts**
Start year for catch time series	From what year onward are catch data deemed reliable?
Relative start and end biomass B/B_o	What is the most likely stock status for the beginning and end of the time series: lightly fished, fully exploited, or overfished?
Relative intermediate biomass B/B_o	Is there an intermediate year in which biomass is considered to have been particularly low or high, e.g., exploitation changed from light to full, or where an extraordinary large year class entered the fishery?
Resilience prior r	What is the best guess for the range of values including natural mortality of adults (M)? Consider the empirical relationship $r \approx 2 \cdot M$.
Resilience prior r	What is the best guess for the range of values including maximum sustainable fishing mortality (F_{MSY})? Considering the relationship $r \approx 2 \cdot F_{MSY}$. Use this question to reinforce or change the answer to previous questions
Resilience prior r	Alternatively, does the prior range of r from the section "Estimates based on models" in the species summary page of FishBase (www.fishbase.org) or SeaLifeBase (www.sealifebase.org) represent the stock adequately?

Table 6. Summary of ME-level assessments benefiting from country experts review, including assessment type, reliability, straddling type, relative biomass type, and end biomass type (in CMSY/BSM assessments). Note summary of the expert review at the bottom of the table.

Data type	Subdata type	Number of stocks
Assessment type	CMSY	940
	Official	691
	Other	11
Reliability	2	384
	3	567
	4	691
Straddling type	Straddling	377
	Non-straddling	1265
Relative biomass type	Abundance	26
	B/B_0	1
	B/B_{MSY}	24
	Averaged/standardized CPUE	35
	Biomass Index	146
	CPUE	315
	Spawning Stock Biomass	84
	Total Biomass	90
	Y/R (yield per recruit)	10
	None (includes official assessments)	911
End biomass type	Expert	457
	Expert and Literature	2
	LBB	20
	Literature	186
	None	977
Expert review	# experts contacted	68
	# experts engaged with positive response	33
	# countries reviewed with SAU experts	51
	# stocks rerun with expert information	875
	# stocks reliability improved	308

Table 7. Comparison of 20 stocks with official assessments available from national or international assessment organizations and BSM assessment results obtained from the CMSY model with added relative biomass time series trends (CPUE or spawning stock biomass). Reference points (*MSY*, B_{MSY}, B_{end}) are expressed in thousands of tonnes. The parameter B_{end} refers to the biomass of the last year of the times series.

	Official assessment results							**BSM analysis results**						
Stock name[1]	***MSY***	F_{MSY}	F/F_{MSY}	B_{MSY}	B/B_{MSY}	B_{end}	B/B_o	***MSY***	F_{MSY}	F/F_{MSY}	B_{MSY}	B_{end}	B/B_{MSY}	B/B_o
arri_tru_e							0.36	3	0.22	0.49	13	16	1.23	0.62
Clup_har_NorthSeaNorwayBarents		0.16	0.82	6368	0.62	3965	0.31	1788	0.22	0.34	8245	11384	1.38	0.69
Euth_aff_Indian	152	0.56	0.98	202	1.15		0.58	63	0.27	1.21	231	227	0.99	0.49
Kats_pel_EAtlantic			1.00		0.90	282	0.45	136	0.33	1.54	413	374	0.91	0.46
Maka_nig_Atlantic	3		1.03		0.69		0.35	6	0.17	3.01	33	14	0.42	0.21
Mela_aeg_NorthSea		0.19	1.13	264	0.90	237	0.45	311	0.16	0.27	1668	731	0.43	0.22
Merl_pro_USCanadaPacific				594	3.58	1312	0.64	287	0.30	0.88	945	1070	1.13	0.57
panu_cyg							0.80	13	0.48	0.33	25	42	1.68	0.84
Poll_vir_Maine		0.27	0.14	125	1.70	212	0.85	14	0.23	0.19	60	90	1.50	0.75
Sard_pil_SEuroAtlanticShelf		0.12	1.43	893	0.17	149	0.08	208	0.19	0.95	836	324	0.39	0.19
Scom_cav_CarolinianVirginianMaine		0.15	0.29	2	1.74	4	0.52	6	0.25	0.45	24	33	1.37	0.69
scom_com_goc							0.32	0	0.34	1.32	1	1	0.75	0.37
Scom_com_Indian	131	0.35	1.28	371	0.89		0.44	172	0.38	1.03	456	469	1.03	0.52
Scom_sco_NEAtlantic		0.23	1.04	5000	0.88	4390	0.44	748	0.30	1.48	2544	2394	0.94	0.47
Ther_cha_EBering			0.65	2147	1.30	2781	0.60	1584	0.23	0.32	6981	11108	1.60	0.80
Thun_ala_Indian	39	0.07	0.85	30	1.80		0.37	43	0.28	0.67	156	209	1.35	0.67
Thun_ala_NCAtlantic	37	0.10	0.54	407	1.36	27	0.68	36	0.27	0.46	133	198	1.49	0.75
Thun_obe_Atlantic	76		1.63		0.59	73	0.30	86	0.30	1.84	282	153	0.55	0.27
Xiph_gla_Indian	31	0.17	0.76	44	1.50		0.75	33	0.29	0.48	113	161	1.43	0.72
Xiph_gla_NCAtlantic	13	0.17	0.78	83	1.04	11	0.52	17	0.26	0.30	66	114	1.71	0.86

[1] Note that we use stock names here and not scientific names because the purpose is to draw attention to the assessment results and not to the species themselves.

The CMSY database

The CMSY database consists of the priors used in the CMSY++ input files (ID and Catch files) and the results of the CMSY++ routine (Output file). This database is curated at Quantitative Aquatics and provided with a version stamp, i.e., each run cycle associated with the reconstructed catch data used (e.g., 2014, 2016 and 2018) is kept in the database. Figure 3 provides a schematic representation of the CMSY database. This database also collates relative biomass time series from official stock assessments or scientific biomass surveys and/or biomass window priors as described in Tables 1-4. It is designed to accommodate new data for stocks that will be added as new species appear in the underlying FAO database updates. For the 2018 update, this database contains data for 2,978 stocks representing 939 exploited species of which 20% are invertebrates and 80% fish stocks (see Appendix G) and of which 75% passed a quality control process[14]. It will be made available via the *Sea Around Us* website. The remaining 25% of these stocks that did not pass quality control will undergo further investigation and will be added as new stocks for CMSY analyses in the next update[15].

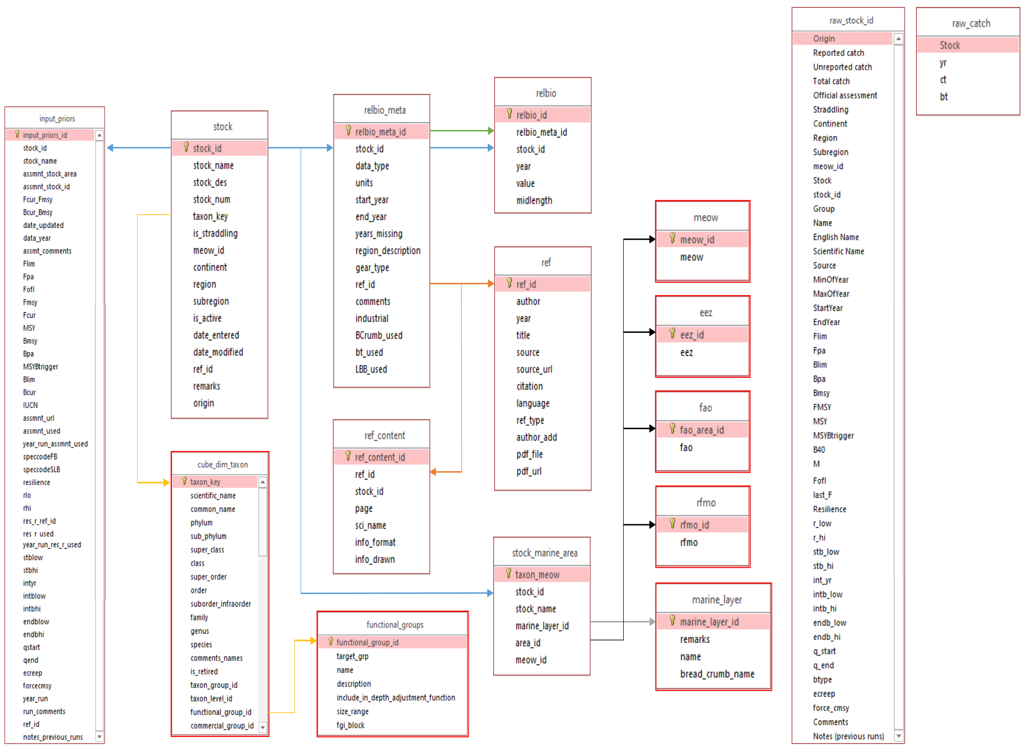

Figure 3. Schematic representation of the CMSY database. Tables with red thick border are existing tables in the *Sea Around Us* database web schema, included here to illustrate the relationship and how the information from those tables are linked to the CMSY schema tables. The ID and Catch input files (i.e., raw_stock_id and raw_catch tables) are raw files based on the provided information from the CMSY schema tables.

[14] This quality control run, the fourth in this long process, verified that the CMSY analyses, notably for stocks run only with catch and resilience data, resulted in logical biomass trends with reasonable default biomass windows.
[15] Meaning when the catch data is updated to the 2019 FAO data.

Applying official assessments for countries or areas with management bodies

Estimating B/B_o for Australia[16]

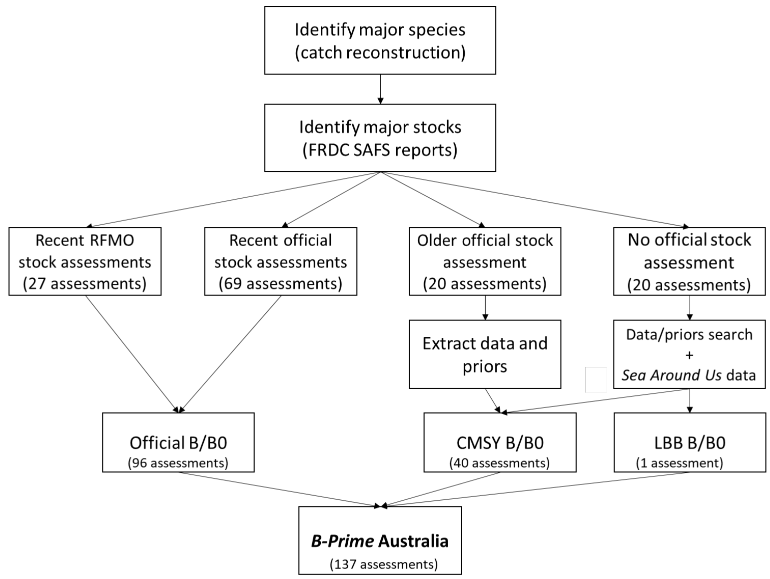

Figure 4. Decision tree for selection of stocks and assessments for B-prime for Australia. CMSY: most recent version of CMSY stock assessment method; LBB: Length-Based Bayesian stock assessment method.

The identification of Australian stocks to be included for assessments followed a systematic approach based on the contribution of each species to the total fisheries catch in the country. First, we utilized the reported component of the Australian catch reconstruction developed by *Sea Around Us*, which compiles the catches reported by the Australian Commonwealth and the various state/territory fisheries authorities, to generate a list of species ranked by total catch. To account for inter-annual variation in catches and trends in recent years, we ranked the species based on the average catches over the entire catch time series available in the catch reconstruction, i.e., reported catches from 1950 to 2018. For each species, we used the individual Status of Australian Fish Stock Reports (SAFS Reports) to identify the number of existing stocks, relative catch by stock (within the species catch), stock distributions and assessments that were available. We obtained the published official stock assessments, i.e., either conducted, commissioned or published by the federal or state/territory fisheries authorities, through online searches, and we extracted the relative biomass values, i.e., B/B_o, when available (Figure 4). Furthermore, we searched for more recent stock assessments and scientific reports published since release of the SAFS reports (2018). We performed this procedure for the species ranked from the highest to the lowest average catch volumes in our species list, aiming to include all species that contributed at least 1% or more of the total Australian catch over the full time series. Our final dataset included a total of 137 stock assessments.

When recent stocks assessments were available, i.e., assessments with time series up to 2016 or more recent, we accepted the values of B/B_o (when available) as the most recent relative biomass estimate of the stock. These provided estimates of B/B_o for 69 stocks included in B-prime (Figure 4). We also accepted the most recent relative biomass estimates of straddling stocks exploited by Australian fisheries but managed and assessed by the RFMOs. These accounted for 27 stock assessments, dating as far back as 2015 (data year).

For stocks without recent official assessment, i.e., assessments prior to 2016, or assessments with no information that allowed for estimates of B/B_o, we extracted the time series of catch and relative abundance, e.g., CPUE, from the most recent stock assessment or scientific report available and conducted independent stock assessments using the most recent version of CMSY. When necessary, we complemented the stock catch time series with the catch data reported in the SAFS reports to account for the most recent years and provide time series to at least

[16] Prepared by Gabriel M.S. Vianna, Amy McAlpine, Rachel White, Dirk Zeller, *Sea Around Us* - Indian Ocean, University of Western Australia, Perth, Australia.

2016 (or more recent). When available, we also extracted from the reports qualitative, e.g., categorical stock status classification, and quantitative, e.g., estimate of relative biomass, information regarding the stocks at the start and intermediate points of the catch time series. Further, we also obtained indicators of the stock's final year relative biomass if clear qualitative information about the stock status at the end of the time series was available. This information was converted to biomass prior ranges, which were used in the CMSY stock assessments according to the methods recommended by Froese *et al.* (2017). This category accounted for 40 additional stock assessments (Figure 4), of which 20 were conducted with relative abundance time series, i.e., BSM stock assessments. We also conducted 20 assessments with *Sea Around Us* reconstructed data and relative biomass priors derived from the literature.

We also conducted Length-Based Bayesian stock assessments (LBB, Froese *et al.* 2018) for species for which no index of abundance was available in the literature, but for which length frequency data could be found. Estimates of B/B_0 obtained from LBB were used as relative biomass priors in the CMSY stock assessments. For one stock, the estimate of B/B_0 provided by LBB for 2016 was accepted as the current B/B_0, given the poor quality of the catch data available for a CMSY assessment.

Estimating B/B_0 for Canada[17]

The federal Department of Fisheries and Oceans (DFO) is the lead authority responsible for conservation and management of Canada's aquatic resources. The Canadian Scientific Advisory Secretariat (CSAS) is responsible for publishing peer-reviewed stock assessments and status reports for targeted species. All existing official Canadian stocks were identified through the CSAS[18] database of stock assessments.

Stocks were defined based on the area specified in the official report, and the corresponding ME was identified. In cases where there were multiple stocks of the same species managed in a single ME, these were treated as 'sub-stocks'. Total catches (for 1990-2018, 1950-2018) derived from SAU reconstructions were then assigned to each sub-stock based on the percentage that a sub-stock contributed to the total catches in the ME.

Reference points and stock status for major stocks were available in the most recent Sustainability Survey for Fisheries (DFO 2018). Where a direct estimate of B/B_{MSY} was missing in the official report, available Limit Reference Points (LRPs) and Upper Reference Points (URPs) were used to determine B/B_{MSY} according to the Precautionary Approach (DFO 2009) (Figure 5).

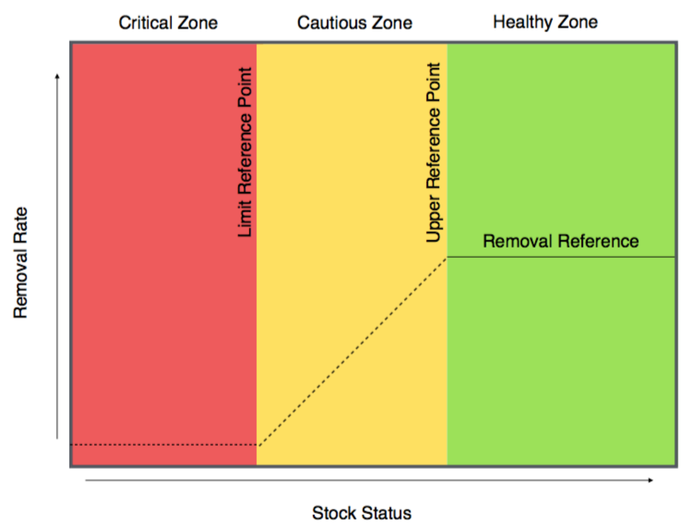

Figure 5. Fisheries management framework with a precautionary approach adapted from DFO (2009). Zones are defined as healthy (biomass ≥ 80% B_{MSY}), cautious (40% B_{MSY} < biomass < 80% B_{MSY}), or critical (biomass ≤ 40% B_{MSY}).

[17] Prepared by Rebecca Schijns, *Sea Around Us*, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, Canada.
[18] CSAS database available at http://www.isdm-gdsi.gc.ca/csas-sccs/applications/Publications/search-recherche-eng.asp

For stocks available in the CSAS database for which no recent official assessment or assessments with no information that could lead to an estimate of B/B_0 could be found, we extracted the time series of catch and relative biomass (e.g., CPUE) from the most recent stock assessment or scientific report available and conducted independent stock assessments using the CMSY++ package. Where only time series of relative biomass were available in official reports, catches were extracted from the *Sea Around Us* reconstruction for the stock in a given EEZ. Since the assessments had an index of abundance available, the BSM results were used for reference points. In cases where qualitative biomass information was available but catch and abundance time series were not available, a CMSY assessment was conducted using SAU reconstructed catches and expert-informed biomass ranges. When the official stock description was based on a smaller area (e.g., based on a group of NAFO zones), then the reported subarea (e.g., NAFO zone) catches were used and the associated Marine Ecoregion was defined to reflect the official management description. The procedure for extracting qualitative and quantitative priors to inform the CMSY++ analysis was the same as the procedure detailed in the Australian methods section shown in Figure 6 for Canada. Our final dataset included a total of 240 stock assessments.

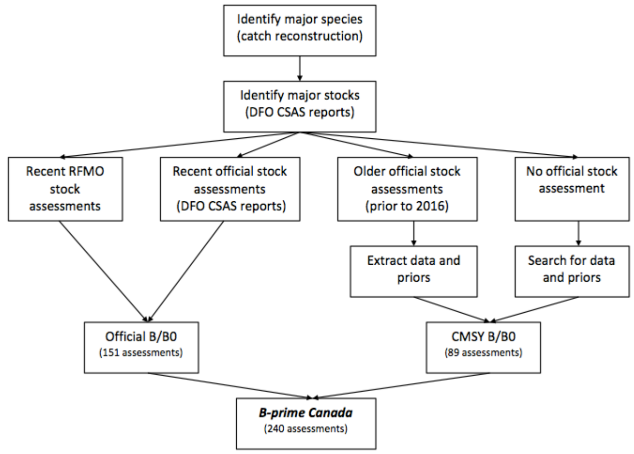

Figure 6. Decision tree for selection stocks and assessments for B-prime in Canada. CMSY: most recent CMSY stock assessment method.

Estimating B/B_0 for New Zealand[19]

The identification of New Zealand's stocks for analysis followed a systematic approach based on the contribution of each stock to the total fisheries catch in the country. The Ministry for Primary Industries of New Zealand provides a comprehensive list of the total annual catches reported at the stock level[20]. We utilized the 2020 data to generate a list of the most important stocks ranked by total catches. To account for inter-annual variation in catches and trends in recent years, we compared these data with the time series of catch data in the historical catches compiled by the *Sea Around Us,* i.e., reported catch from 1950 to 2018, to identify stocks with large historical catches

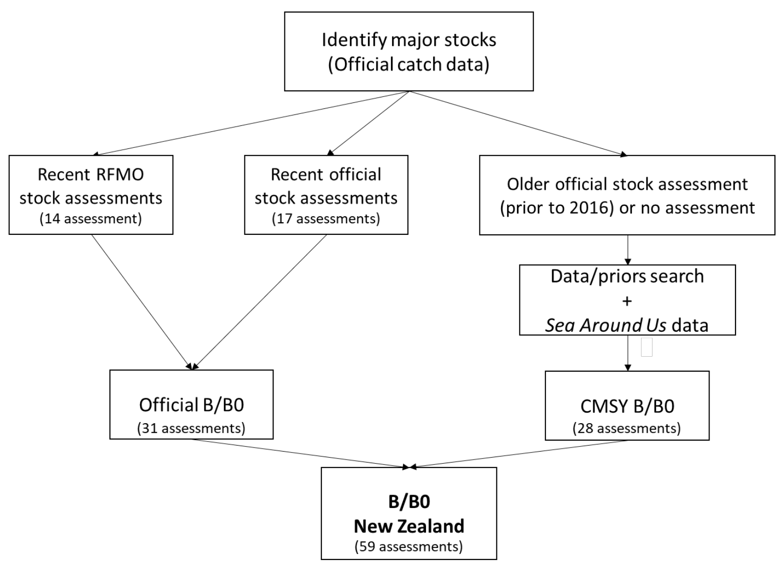

Figure 7. Decision tree for selection of stocks and assessments for B-prime in New Zealand. CMSY: most recent CMSY stock assessment method

[19] Prepared by Gabriel M.S. Vianna, Amy McAlpine, Rachel White, Dirk Zeller, *Sea Around Us* - Indian Ocean, University of Western Australia, Perth, Australia
[20] https://fs.fish.govt.nz/Page.aspx?pk=16&tk=114

that should be included in our analysis. Our final dataset included a total of 59 stock assessments.

For each stock included in our list, we searched the 2019 and 2020 Fisheries Plenary Assessment reports, e.g., Fisheries New Zealand (2020), to obtain the most up-to-date information on stock status and stocks assessments available. We then sourced the published official stock assessments identified in the plenary reports through online search and extracted the relative biomass values, i.e., B/B_0, when available (Figure 7). We performed this procedure for the species ranked from the highest to the lowest catch in our species list, aiming to include all the stocks that contributed at least 1% or more of the total national catch over the time series. We further searched for stock assessments published by the regional RFMO for pelagic straddling stocks exploited by New Zealand. When recent stocks assessments were available, i.e., stock assessments with time series up to at least 2016, we accepted the values of B/B_0 (when available) as the most recent relative biomass estimate of the stock. These resulted in estimates of B/B_0 for 17 stocks (Figure 7). We also accepted the most recent relative biomass estimates of straddling stocks exploited by fisheries in New Zealand but managed and assessed by the RFMOs, which accounted for 14 stock assessments (Figure 7).

For stocks without recent official assessments, i.e., no later than 2015, or assessments with no information that allowed for estimates of B/B_0, we extracted the time series of catch and relative abundance (e.g., CPUE) from the most recent stock assessment or scientific report available and conducted independent stock assessments using the most recent version of CMSY. When necessary, we complemented the stock catch time series with the catches reported in the Fisheries Plenary Assessment to account for the most recent years and provide updated time series for the assessments, i.e., for 2016 or more recent, or used the *Sea Around Us* reconstructed data for stocks we found no time series for. Furthermore, we extracted from technical reports qualitative and quantitative information, e.g., estimate of relative biomass, regarding the stocks at the start and intermediate points of the catch time series. We also obtained indicators of the stock's final year relative biomass if clear qualitative information about the stock status at the end of the time series was available. This information was converted to conservative biomass prior ranges, which were used in the CMSY stock assessments according to the methods recommended by Froese *et al.* (2017). This category accounted for 28 additional stock assessments (Figure 7), all of which were conducted with relative abundance time series, i.e., BSM stock assessments.

Estimating B/B_0 for the USA[21]

The National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce is the central government agency responsible for managing fisheries and providing scientific information on the state of the nation's oceans. After passing the Magnuson-Stevens Fishery Conservation and Management Act in 1976, eight regional fishery management councils were created and required to provide fishery management plans, develop rebuilding plans, and set catch limits. As well, three Interstate Marine Fisheries Commissions coordinate data collections and fisheries management with NOAA. NOAA publishes Fisheries' Stock Status, Management, Assessment, and Resource Trends online through the Stock SMART web tool. Therefore, the majority of stock assessments and supporting information were sourced from the NOAA publication database and associated councils and commissions for each USA EEZ (Table 8).

Territories and islands were included in the search for official assessments. However, the majority did not have information available for non-RFMO managed stocks. Thus, they were assessed using CMSY (Figure 8). Our final dataset included a total of 339 stock assessments.

[21] Prepared by Emmalai Page and Rebecca Schijns, *Sea Around Us,* Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, Canada

Table 8. Source of stock assessments and fishery management advice for each USA EEZ including islands and territories. For EEZs where the source is 'Not available', the stocks were assessed using reconstructed catches and CMSY.

EEZ	Source
American Samoa	NOAA
Guam (USA)	NOAA
Hawaii Main Islands (USA)	NOAA
Hawaii Northwest Islands (USA)	Not available
Howland & Baker Isl. (USA)	Not available
Jarvis Isl. (USA)	Not available
Johnston Atoll (USA)	Not available
Palmyra Atoll & Kingman Reef (USA)	Not available
Puerto Rico (USA)	Not available
US Virgin Isl.	Not available
USA (Alaska, Arctic)	Not available
USA (Alaska, Subarctic)	NOAA, PFMC
USA (East Coast)	NOAA, SEDAR, ASMFC, NEFSC
USA (Gulf of Mexico)	SEDAR, GSMFC
USA (West Coast)	NOAA, PFMC
Wake Isl. (USA)	Not available

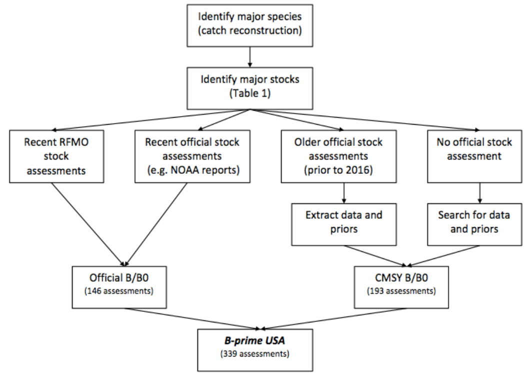

Figure 8. Decision tree for selection stocks and assessments for B-prime in USA, including territories and islands. CMSY: most recent CMSY stock assessment method

Special case I: Assessing the marine resources of China and neighboring countries[22]

While the marine fisheries of the People's Republic of China (henceforth: China) generate by far the highest catch in the world (FAO 2020), China's fisheries statistics are rather problematic. Thus, a large fraction of China's domestic catch is reported on in national statistics as 'miscellaneous fish' category with only a few fishes (e.g., hairtail *Trichiurus haumela*) reported at the level of species (China Fishery Statistical Yearbook 2018).

Therefore, the catch provided for China by *Sea Around Us* is a hybrid: the annual total and the catches of a few identified species are reported unchanged while the remaining 'miscellaneous fish' – representing about 80% of the total – is interpolated from the detailed composition of marine catches in Taiwan and South Korea (Pauly and Le Manach 2015, Tsui *et al.* 2021; see www.seaaroundus.org).

This procedure allowed for the production of catch maps and similar products for the East and Southeast Asian regions (see e.g., Pauly and Liang 2019). However, this procedure could not generate the reliable catch time series required for stock assessments using the CMSY/BSM method as provided by the *Sea Around U* for other data-sparse regions, e.g., West Africa (see Palomares *et al.* 2020).

We therefore decided to (1) create a Special Topic issue of the peer-reviewed journal *Frontiers in Marine Science* devoted to the "Status of Fisheries in East Asia," and (2) teach a stock assessment course in China to generate enough publishable assessments of Chinese marine stocks so that the status of China's domestic exploited stock would be reliably assessed.

[22] Prepared by Daniel Pauly, *Sea Around Us*, Institute for the Fisheries and Oceans, University of British Columbia, Vancouver, Canada and Cui 'Elsa' Liang, Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China.

The course, held in Qingdao, Shandong Province, China from June 18 to 20, 2019, was taught by Drs Maria-Lourdes Palomares, Daniel Pauly, and Rainer Froese[23]with Drs Weiwei Xian and Cui 'Elsa' Liang of the Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences serving as co-instructors, facilitators, and hosts. The course, which was attended by about 20 participants from research institutions along the Chinese coast, was very successful in that it led to 15 contributions that were, after thorough peer-review, accepted for publication in the Special Topic issue of *Frontiers in Marine Research,* of which 14 contained stock assessments (see Table 9 and 10). Overall, these contributions, which are summarized in Pauly et al. (2021), present 161 original stock assessments covering numerous fish and invertebrate species in China and neighboring countries. The stock assessment approach used in the majority of cases was the CMSY method (Table 9), based on locally available time-series and usually complemented with catch-per-effort data that allowed the analyses to be extended to the BSM method. These, and assessments using other methods yielded 161 estimates of the fraction of biomass remaining relative to carrying capacity (B/B_o).

Despite the well-known inadequacies of fisheries statistics in China, the over-exploited status of its domestic fisheries could be reliably inferred from the many converging analyses of a large number of stocks (Table 11). Also, this exercise contributed numerous assessments of stocks in adjacent countries and/or countries with which China share stocks, notably South Korea and Japan.

Table 9. Number of stocks (or populations) assessed, by method; the numbers after the plus sign (if any) refer to invertebrates (mainly squids), the others to fishes.

Location	**CMSY/BSM**	**LBB**	**Y/R**	**Sum**	**Studies**
Chinese Mainland	19	28+15	21	68+15	Liang *et al.*, (2020a ; 2020b); Wang *et al.* (2020a, 2021); Zhai and Pauly (2019); Zhai *et al.* (2020); Zhang *et al.* (2020a).
Taiwan	17	5	--	22	Ju *et al.* (2020a, 2020b); Liang *et al.* (2020b).
South Korea	5+1	--	--	5+1	Liang *et al.* (2020b)
Japan	37+13	--	--	37+13	Liang *et al.*, (2020b); Ren and Liu (2020); Wang *et al.* (2020b, 2020c; Zhang *et al.* (2020b).
Sum	78+14	33+15	21	132+29	This 'Research Topic'

Table 10. Number of stocks (or populations) assessed, by location, with the mean fraction of 'biomass left' in recent years (B_{end}) relative to the unexploited biomass (B_o), and its standard deviation. No. = number of stocks; SE = standard error.

Location	**No.**	**Mean B_{end}/B_o**	**SE**	**Studies**
Chinese Mainland	83	0.254	0.023	Liang *et al.* (2020a, 2020b; Wang *et al.* (2020a, 2021); Zhai and Pauly (2019); Zhai *et al.* (2020); Zhang *et al.* (2020a).
Taiwan	22	0.163	0.038	Ju *et al.* (2020a, 2020b); Liang *et al.* (2020b).
South Korea	6	0.257	0.021	Liang *et al.* (2020b)
Japan	50	0.297	0.021	Liang *et al.* (2020b); Ren and Liu (2020); Wang *et al.* (2020b, 2020c); Zhang *et al.* (2020b).
Sum or mean	161	0.255	0.015	---

[23] Dr Rainer Froese participated remotely.

Special case II: Assessing the marine fish and invertebrate stocks in Northwest Africa[24]

In West Africa, one often hears "there are no data" with which to perform stock assessments, but this is not the case. This was demonstrated in a training course titled "*Utilisation de la méthode CMSY pour l'évaluation des stocks ouest-africains*" held from September 23-27 2019 in Dakar, Senegal. The course was hosted by the Regional Sub-Commission for Fisheries (*Commission Sous-Régionale des Pêches, CSRP*) with the support of the MAVA Foundation for participants from Cape Verde, The Gambia, Guinea, Guinea-Bissau, Liberia, Mauritania, Senegal, and Sierra Leone. The stock assessment methods that were taught, CMSY and LBB, requiring a minimum amount of data to provide estimates of B/B_{MSY}, i.e., the current biomass of an exploited stock relative to the biomass that generates maximum sustainable yield (MSY).

The course was successful in that delegates from each of the participating countries contributed applications of the CMSY and/or LBB method based on data that they brought along. However, a number of these applications should be considered to be very preliminary. In the LBB case, the length-frequency (L/F) data that were analyzed did not necessarily reflect the wealth of L/F data available in the CSRP countries. In the CMSY cases, the national data used did not generally reflect the fact that the stock in question (e.g., of sardinella) may range over the Exclusive Economic Zones (EEZ) of two or more CSRP countries.

The short contributions presented in Palomares *et al.* (2020a) should therefore be seen as tentative in terms of their specific results. However, what they certainly do express is that the CMSY and LBB methods are well-suited for use in the CRSP region and that the course participants will be using these methods in the future.

To illustrate the power of international cooperation and to obtain reliable assessments of small pelagic stocks in the CSRP area, a chapter was added detailing how national data can and should be pooled into (sub-)national assessments of 14 shared stocks of small pelagic fishes (Palomares *et al.* 2020b). Table 11 present its key results. The general conclusions from the training course and the stock assessments it generated were:

- There are enough L/F and catch data series in the CRSP region for stock assessments to be performed, i.e., it is no longer the case that "there are no data"; and
- Policymakers in the CRSP region must face up to the fact that the assessment of the major stocks in the region indicates overexploitation, and in order to maintain abundant catches, a reduction of fishing effort is necessary.

[24] Prepared by Maria L.D. Palomares and Jessika Woroniak, *Sea Around Us,* Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, Canada.

Table 11. List of small pelagic species assessed by Palomares *et al.* (2020b) in Northwest Africa. The catches (in thousands of tonnes) and B/B_{MSY} values are annual averages for the EEZ listed and the period 2012-2016.

Scientific name	English name	EEZ occurrence	Catch	B/B_{MSY}	Stock status
Caranx rhonchus	False scad	Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea, and Sierra Leone	14.0	0.59	Overfished
Decapterus macarellus	Mackerel scad	Mauritania, Cape Verde Senegal, Gambia, G.-B, Guinea, Sierra Leone	2.92	0.41	Grossly overfished
Engraulis encrasicolus	European anchovy	Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea, and Sierra Leone	139	0.46	Grossly overfished
Ethmalosa fimbriata	Bonga shad	Mauritania, Senegal, and Gambia	85	0.91	Slightly overfished
Ethmalosa fimbriata	Bonga shad	Guinea-Bissau, Guinea, and Sierra Leone	157	0.90	Slightly overfished
Ilisha africana	West African ilisha	Guinea-Bissau, Guinea, and Sierra Leone	9.21	1.5	Healthy
Mugil cephalus	Flathead grey mullet	Mauritania, Senegal, and Gambia	12.1	1.3	Healthy
Sardinella aurita	Round sardinella	Mauritania, Senegal, and Gambia	312	0.74	Overfished
Sardinella aurita	Round sardinella	Guinea-Bissau, Guinea, and Sierra Leone	87.2	0.38	Grossly overfished
Sardinella maderensis	Madeiran sardinella	Mauritania, Senegal, and Gambia	199	0.74	Overfished
Sardinella maderensis	Madeiran sardinella	Guinea-Bissau, Guinea, and Sierra Leone	53.3	0.79	Overfished
Sardina pilchardus	European pilchard	Mauritania, Senegal, and Gambia	1025	0.88	Slightly overfished
Trachurus trachurus	Atlantic horse mackerel	Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea, and Sierra Leone	105	0.92	Slightly overfished
Trachurus trecae	Cunene horse mackerel	Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea, and Sierra Leone	124	1.1	Healthy

Special case III: Assessing the marine fish and invertebrate stocks in the waters of India[25]

One of the earlier stock assessment training courses applying the CMSY method was conducted with experts from the Central Marine Fisheries Research Institute (CMFRI) in Kochi (Kerala, India) in October 2017 with support from the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ). This workshop introduced Indian fisheries scientists at the CMFRI to the then very new CMSY method and the use of resilience and related estimates from FishBase (see Palomares and Froese 2017). The participants identified 7 commercially exploited species (see Table 12) with data from the CMFRI database of catch time series by gear, fishing area (state) and species, and also where real-time fisheries abundance data from multistage stratified

[25] Prepared by Gabriel Vianna, *Sea Around Us* - Indian Ocean, University of Western Australia, Perth, Australia.

random sampling (Banerji and Charkraborty 1973; Devaraj and Vivekanandan 1999; Mohan Joseph and Jayaprakash 2003; Srinath *et al*. 2006) was available.

Table 12. Preliminary assessments of 7 commercially important stocks in the waters of India resulting from the CMSY workshop in Kochi, India (see Palomares and Froese, 2017).

Species	**Locality**	**Year range**	**Gear**	B_{end}/B_{MSY}	**Source**
Nemipterus japonicus	Chennai	1979-2003	Not available	0.5	Dash *et al*. (2017)
Rastrelliger kanagurta	South Kerala	1991-2014	Seines, gillnets and trawls	0.3	Sathianandan *et al*. (2017)
Sardinella longiceps	India	2000-2015	Seines	0.5	Ganga *et al*. (2017)
Saurida undosquamis	Chennai	1987-2009	Trawl	0.3	Kizhakudan *et al*. (2017)
Tenualosa ilisha	Bangladesh	1987-2016	All gears	1.0	Al-Mamun *et al*. (2017)
Thunnus albacares	Indian Ocean	1950-2016	All gears	0.7	Vivekanandan *et al*. (2017)
Trichiurus lepturus	Karnataka	2005-2015	Trawlers	0.8	Dineshbabu *et al*. (2017)

This early workshop showed that it is possible to provide stock status reference points for data-limited stocks. More importantly, it illustrated the need to publish information on the life history traits and fisheries-related data of a country's exploited stocks. This need has since been fulfilled for India by Mohamed *et al*. (2021) and Sathianandan *et al*. (2021); the results of the latter were used to inform the CMSY analyses of 62 Indian species-level stocks representing 11 species (see Table 13).

Table 13. List of species-level stocks with biological reference points from Sathianandan *et al.* (2021) used in CMSY assessments to inform stocks from Indian Ocean MEs.

Scientific name	**Andhra Pradesh**	**Gujurat and Daman Diu**	**Karnataka**	**Kerala**	**Maharashtra**	**Odisha**	**Puducherry**	**Tamil Nadu**	**Goa**	**West Bengal**	**Sub stocks**
Euthynnus affinis	1		1	1	1	1	1	1	1		8
Harpadon nehereus	1		1			1	1				4
Katsuwonus pelamis	1				1				1		3
Megalaspis cordyla	1			1	1	1	1				5
Parastromateus niger	1	1		1	1	1			1		6
Rastrelliger kanagurta	1			1	1	1	1		1		6
Sardinella longiceps		1		1	1	1		1	1		6
Scomberomorus commerson			1	1	1	1	1	1	1		7
Scomberomorus guttatus	1		1	1	1	1			1	1	7
Scylla serrata			1	1	1	1	1		1	1	7
Tenualosa ilisha			1			1				1	3
	7	**2**	**6**	**8**	**9**	**10**	**6**	**3**	**8**	**3**	**62**

Special case IV: Assessing the marine fish stocks in Philippine waters[26]

Two stock assessment workshops were conducted in the Philippines, a preliminary workshop in January 2017 hosted at Quantitative Aquatics in Los Baños, and a follow-up workshop in March 2019 hosted by the National Fisheries Research and Development Institute (NFRDI) in Quezon City, Philippines. Participants of both workshops were from the National Stock Assessment Program (NSAP) and are involved in the collection of statistics data for fisheries management.

The first workshop's goal was to introduce and demonstrate the application of an earlier version of CMSY on *Sea Around Us* reconstructed catches for the Philippines in a 6-hour session to a handful of NSAP participants. The demonstration assessments were informed by independent estimates of CPUE data used in Palomares and Pauly (2014) for *Decapterus macrosoma*, *Katsuwonus pelamis*, *Rastrelliger kanagurta* and *Sardinella fimbriata*. The NSAP participants subsequently practiced CMSY analyses on *Decapterus macrosoma*, *Encrasicholina punctifer*, *Katsuwonus pelamis*, and *Sardinella tawilis* catch data with varying time series lengths covering 1998-2015.

The second workshop aimed to provide a complete set of instructions and hands-on analyses of Philippine stocks from the 12 marine Philippine Fisheries Management Areas (FMA)[27] and some freshwater regions. Time series of catch data originally reported by fishing region were obtained from the NSAP database and aggregated by FMAs during the workshop. Some regional L/F data collected from commercial fleets in 2014-2016 were used to estimate end biomass windows for some of these stocks. Unfortunately, CPUE time series were lacking for most of the species analyzed. Although most of the data brought by participants did not meet the requirements for CMSY analysis, some of the results for better studied stocks presented in Table 14 can be used to propose preliminary management schemes. The lack of open-access data also prompted the workshop participants to submit their work to the Philippine Journal of Fisheries, some of which are now in the review process.

Table 14. Preliminary results of stock assessments in some Philippine marine and freshwater regions presented at the *Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks*, 4-8 March 2019, Quezon City, Philippines. FMA = Fisheries Management Area.

FMA	Region	Stocks	Years	B_{end}/B_{MSY}	Source
1	Batanes, Babuyan Channel, Isabela, Aurora, Benham Rise, Lagonoy Gulf, Lamon Bay.	*Trichiurus lepturus*	2008-'18	0.3	Villarao *et al.* (2019)
3	Zamboanga Peninsula, Autonomous Region in Muslim Mindanao	*Decapterus macarellus,*	2008-'17	0.15	Cecilio *et al.* (2019)
		Selar crumenophthalmus	2008-'17	0.67	
4	Sulu Sea	*Sardinella lemuru*	2008-'17	0.60	Ignacio *et al.* (2019)
5	Palawan, Mindoro, Antique	*Decapterus macrosoma*	2008-'17	0.61	Candelario *et al.* (2019)
6	West Philippine Sea, Manilla Bay	*Decapterus macarellus*	2003-'16	0.6	Gaerlan *et al.* (2019)

[26] Prepared by Maria L.D. Palomares, *Sea Around Us,* Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, Canada

[27] FMAs were defined in the Bureau of Fisheries and Aquatic Resources (BFAR) Fisheries Administrative Order 263 dated January 28 2019. The reorganization of the 20 fishing regions into 12 FMAs is an attempt by the BFAR to restructure stock assessment according to ecosystems. At the time of the workshop, the organization of fishing regions into FMAs was just being finalized, and thus catch data organized by FMA was still not available.

		Selar crumenophthalmus,	2003-'16	0.52	
		Sardinella gibbosa	2003-'16	0.5	
8	Samar and Leyte Isl., Panaon Isl., NE Mandanao Isl., Dinagat Isl.	*Photopectoraliss bindus*	2001-'17	0.20	Alcantara and Amigo (2019)
9	Bohol Sea	*Sardinella lemuru*	2002-'11	0.55	Casinillo *et al.* (2019)
11	Visayan Sea	*Decapterus macrosoma*	2008-'17	0.51	Abrenica *et al.* (2019)
11	Visayan Sea	*Sardinella gibbosa*	1998-'17	0.2	Mesa *et al.* (2019)
12	Tayabas Bay, Calatgan Bay, Balayan Bay, Tablas Strait, Sibuyan Sea	*Sardinella lemuru*	2004-'17	0.51	Ramos *et al.* (2019)

Selection of stocks and stock assessments for RFMOs[28]

Regional Fisheries Management Organizations (RFMOs) are international bodies made up of many countries that have a shared interest in managing and conserving tunas and other large pelagic fishes covering wide oceanic distributions. These stocks are fished within EEZs and primarily in the high seas. There are 17 established RFMOs that cover various areas, sometimes with overlapping areas. There are five main RFMOs managing commercially important tunas and other large pelagic fisheries, altogether covering around 91% of the world's oceans (Pew Charitable Trusts 2012; Figure 9).

Recent, official stock assessments were available for the majority of RFMO-managed tunas and large pelagic species such as swordfishes, marlins and sharks. Ten stocks with Pacific-wide distributions are co-managed by IATTC and WCPFC and noted as joint IATTC-WCPFC stocks in the database. Catch time series were extracted from figures or tables available in the stock assessment or supporting documents. In addition, catch time series for three stocks were extracted from the RAM Legacy Stock Assessment Database by filtering for the stock identification and most recent TC-Best time series. These catch time series were used to fill the 'total catch in ME/RFMO over period assessed' column in the main B' output parameters template.

Overall, 47 individual stocks were included with official RFMO estimates (Table 15). The list of official stock advice used in the RFMO assessments is in Appendix B.

Catch distribution to EEZ-level

Each RFMO stock was assigned EEZ-level rows corresponding to the FAO areas that the stock was distributed within. Specific areas were noted in the 'comments' section. The total catches for 1950-2018, 1990-2018, and 2018 for each stock in each EEZ was provided from the *Sea Around Us* catch database. This database was preferred because of its inclusion of unreported estimates, spatial resolution of catches assigned to half-degree by half-degree cells, and time series covering 1950-2018. In some cases, the EEZ was blank, thus in order to include the EEZ in the overall weighing score, a routine to fill the blanks was applied.

The routine used the %EEZ within RFMO area for all RFMOs included by the official stock assessments. Blank catch totals were calculated by using the official catch time series total (for 1950-2018, 1990-2018, and 2018), the

[28] Prepared by Rebecca Schijns, Maria Donaghey, Sydney Baxter and Maria L.D. Palomares, *Sea Around Us*, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, Canada

fraction each EEZ is covered by the RFMO, summing the total fraction and redistributing the ratio across all the EEZs that are covered by the RFMO area.

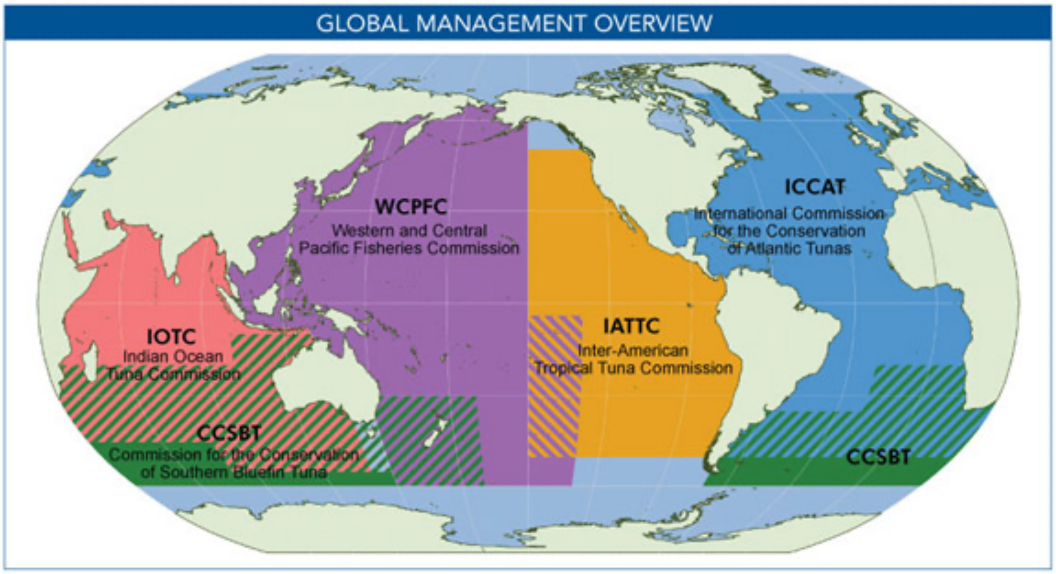

Figure 9. Five main RFMOs covering 91% of the world's oceans. Image adapted from Pew Charitable Trusts (2012).

Table 15. The number of stocks that had official stock assessments available by 6 RFMOs and corresponding webpage. A number of tunas and large pelagic species with a Pacific-wide distribution are co-managed by IATTC and WCPFC and noted in the bottom row.

RFMO	Stocks w/ assessments	Website
CCBST – Commission for the Conservation of Southern Bluefin Tuna	1	https://www.ccsbt.org/en/content/latest-stock-assessment
IATTC – Inter-American Tropical Tuna Commission	3	https://www.iattc.org/StockAssessmentReportsENG.htm
ICCAT – International Commission for the Conservation of Atlantic Tunas	13	https://www.iccat.int/en/assess.html
IOTC – Indian Ocean Tuna Commission	14	https://www.iotc.org/science/status-summary-species-tuna-and-tuna-species-under-iotc-mandate-well-other-species-impacted-iotc
SPRFMO – South Pacific Regional Fisheries Management Organisation	1	https://www.sprfmo.int/science/species-profiles/
WCPFC – Western and Central Pacific Fisheries Commission	5	https://www.wcpfc.int/current-stock-status-and-advice
WCPFC – IATTC (co-managed Pacific stocks)	10	http://isc.fra.go.jp/reports/stock_assessments.html ; https://swfsc-publications.fisheries.noaa.gov/publications/ ; https://www.wcpfc.int/current-stock-status-and-advice

ICES Stock Assessments[29]

The International Council for the Exploration of the Sea (ICES) is an intergovernmental marine science organization that aims to advance and share scientific understanding of marine ecosystems and the services they provide and to use this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals (ICES, n.d. a).

There are 20 ICES member countries (Table 16): Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Lithuania, The Netherlands, Norway, Poland, Portugal, Russian Federation, Spain, Sweden, United Kingdom, United States of America (ICES, n.d. b). As Canada and the United States of America are treated separately in this report, they are excluded here. On the other hand, Greenland and the Faeroe Islands were included in the ICES stock assessment, despite not being listed as member countries.

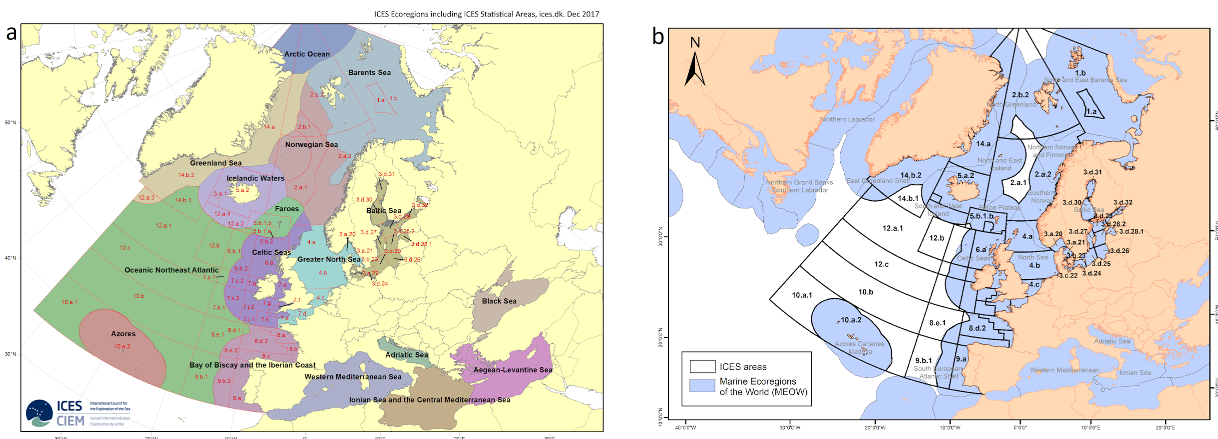

Figure 10. ICES fishing areas with (a) ICES ecoregions and (b) Sea Around Us Marine Ecoregions. (Adapted from http://www.ices.dk/data/Documents/Maps/ICES-Ecoregions-hybrid-statistical-areas.png)

The ICES fishing areas and ecoregions all occur within FAO Major Fishing Area 27 (Figure 10). The ICES fishing areas were developed for the collection of fisheries statistics, as opposed to the ICES ecoregions, which were developed to provide more ecosystem-based advice on fishing opportunities and management. Both ICES (Figure 10a) and *Sea Around Us* ecoregions (Figure 10b) are biogeographical and oceanographical boundaries used to demarcate the distribution of pelagic and benthic species and communities. ICES ecoregions are additionally adapted in response to changes in management areas and input from policy developers since it covers all the ICES fishing areas that provide catch data. All fish stocks in the ICES stock assessment are associated with the relevant ecoregion or collection of ecoregions, while the ICES areas in the stock name indicate where the catch data was collected (ICES 2020).

[29] Prepared by Maria Selina Conchitina A. De Leon, Luisa R. Abucay, Vina Angelica A. Parducho and Maria Lourdes D. Palomares, Quantitative Aquatics, Inc., IRRI Khush Hall, College, Los Baños, Laguna, Philippines

ICES data used

Two main sources of data from ICES were used to fill up the B' output parameters template: official ICES stock advice and catch data. Official ICES stock advice is centered on a precautionary approach within an MSY framework in the context of an ecosystem-based approach. It functions to inform policies for high-yield sustainable fisheries (ICES 2012). ICES assessments used in the official stock advice involves a relationship between fishing mortality rates, average catches, and average stock size. Depending on the available data and characteristics of stocks, ICES uses different biomass reference points to estimate the desired fishing mortality rate and total allowable catch that will give maximum yields but will not negatively impact recruitment.

The list of official stock advice used in the ICES assessments is listed in Appendix C. On the other hand, three different sets of catch data (Table 17) were downloaded to account for the different year ranges of the available datasets.

Table 16. Countries included in the ICES stock assessments with the corresponding EEZ and ISO3 code used in the B' output parameters table.

Country	EEZ	ISO3 Code
Iceland	Iceland	ISL
Greenland	Greenland (Denmark)	GRL
Portugal	Portugal (mainland)	PRT
Spain	Spain (Northwest)	ESP
United Kingdom	United Kingdom (UK)	GBR
Russian Federation	Russia (Barents Sea)	RUS
France	France (Atlantic Coast)	FRA
Norway	Norway	NOR
Ireland	Ireland	IRL
Belgium	Belgium	BEL
Faeroe Islands	Faeroe Isl. (Denmark)	FRO
Netherlands	Netherlands	NLD
Germany	Germany (Baltic Sea)	DEU
	Germany (North Sea)	DEU
Denmark	Denmark (North Sea)	DNK
	Denmark (Baltic Sea)	DNK
Poland	Poland	POL
Sweden	Sweden (West Coast)	SWE
	Sweden (Baltic)	SWE
Lithuania	Lithuania	LTU
Finland	Finland	FIN
Estonia	Estonia	EST
Latvia	Latvia	LVA

Table 17. ICES catch data used in the Sea Around Us assessments. Since ICES stocks and statistical areas are well defined, we treated ICES in the same manner as we treated RFMOs, although each country reported national catch per stock.

Dataset	**Filename**	**Description**	**Source URL**
Official Nominal Catches 2006-2018	ICESCatchDataset2006-2018 (in .xls and .csv format)	Catches in FAO area 27 by country (2 letters country code), species (3 letters Species/FAO code), area (presented as numbers instead of Roman Numerals) and year as provided by the national authorities for 2006 to 2018 only.	https://www.ices.dk/data/Documents/CatchStats/OfficialNominalCatches.zip
Historical Nominal Catches 1950-2010	ICES_1950-2010 (in .xls and .csv format)	Catches in FAO area 27 by country (full country name), species (FAO name), area (Division code presented as Roman Numerals) and year for 1950 to 2010 only.	https://www.ices.dk/data/Documents/CatchStats/HistoricalLandings1950-2010.zip
ICES Historical Landings 1903-1949	1903-1949_Landings (in .xls and .csv format)	Catches in FAO area 27 by country (3 letters country code), year, area (FAO_Area presented as Roman Numerals) and species (combination of 3 letters FAO species code, species name and scientific name) for 1903 to 1949 only.	https://www.ices.dk/data/Documents/CatchStats/ICES1903-49.zip

Data harmonization

Data from the official stock advice was extracted using an R script. Note that the catches from different stocks were calculated separately so that they could be properly disaggregated into the catch of the respective countries. A proxy B_{MSY} was estimated per stock as 2*B_{pa} (i.e., precautionary reference point for the spawning stock biomass; see ICES 2012). The start year was obtained from the Stock Assessment Graphs (ICES, n.d. c) or via the Official ICES Advice reports presented in Appendix C.

Catch data per stock per country were downloaded from ICES (n.d. d), which included catch statistics for the: 1) 1903-1949; 2) 1950-2010; and 3) 2006-2018 in different formats. These data files had variating formats for ICES areas names, species name/FAO name had different species code, and country names also had different country codes. The 1950-2010 dataset was harmonized with the 2006-2018 dataset by matching the FAO species name with the combination of FAO species name, scientific names and species code used in the latter, and renaming the 1950-2010 dataset ICES areas with the corresponding current ICES areas. These were done to match the format of stock names used in the CMSY analyses. Only data for the period 1950-2005 was used of dataset (2).

Substocks for each ICES stock with multiple ICES fishing areas were identified. For instance, her.27.6a7bc is a herring stock with different catch levels in ICES areas 27.6.a, 27.7.b, 27.7.c.1, and with thus three substocks for each area. Catch extraction was done by matching the parameters, e.g., country, species code, ICES area, year with the reference files. Note that in the 1950-2005 catch dataset, Germany is listed as: Germany, Germany, Fed. Rep. of, and Germany, New Länder while the UK is listed as: UK - Eng+Wales+N.Irl. and UK - Scotland. Catch of stocks assigned to the USSR (1951-1991) was disaggregated to the former country members included in the assessment (Russia, Lithuania, Latvia) by applying the 2006-2018 percent catch of stock each country had for the stock concerned to the USSR catch.

Discussion

The work documented in this report establishes that it is possible to perform assessments for the bulk of the stocks exploited by marine fisheries throughout the world given two conditions: 1) one has a team willing and capable of performing an immense amount of work; and 2) one has access to a versatile stock assessment tool, capable of generating good results when data are very scarce, but also of incorporating ancillary data where available.

The *Sea Around Us* team accomplished this task because of the support of many colleagues worldwide, many of whom had earlier contributed to the catch reconstructions that enabled us to produce the long catch time series, currently ranging from 1950 to 2018. Additionally, the close collaboration of the *Sea Around Us* with the Philippine-based team that maintains FishBase and SeaLifeBase facilitated the identification of priors for numerous applications.

Also, our close collaboration with Dr. Rainer Froese (and his colleagues), the developer(s) of the CMSY and related methods, allowed us to complete this massive task. The CMSY++ software tool we used is singular in its ability to provide reasonable results in very data-sparse situations – such as prevail in some tropical developing countries – and to smartly accommodate additional data sets where available, which reduced the uncertainty associated with the results.

We made ample use of the latter property and used all of the official assessments we could find to constrain the CMSY outputs. This included most of the contents of the well-known RAM Legacy Stock Assessment Database, the assessments of countries with numerous stocks that are regularly evaluated (USA, Australia, Canada, New

Zealand, etc.), and from the RFMOs and other supranational bodies such as the E.U. and FAO. Thus, it will not be possible to contrast our assessments with those of other entities because, in many cases, we built on the previous assessments of these other entities.

We paid particular attention to countries and regions often overlooked in global assessments, supposedly because they have 'no data.' We have emphasized Asia - particularly China - and West Africa, both with massive fisheries catches, but commonly ignored in 'global' analyses.

For most of our assessments, we used the CMSY++, a complete description of which is presently under peer-review (Froese *et al.*, manuscript). This version addresses the issues some colleagues identified as problematic in the earlier CMSY version.

In other publications, we used CMSY++ to assess a 500-year time series of Northern cod in Canada (Schijns *et al.* 2021). We also demonstrated the pernicious effect of truncating the time series of catches used for stock assessments (Schijns and Pauly, 2021), a practice commonly used in official stock assessment and which usually generates over-optimistic results. For this reason, as many as possible of our assessments were based on catch reconstructed back to 1950. Therefore, we are confident that the stock assessments presented in the present report represent the state-of-the-art in terms of their methodology. As a whole, they will reflect the major trend of the biomass exploited by commercial fisheries in the world.

Acknowledgements

This *Sea Around Us* initiative was completed with the greatly appreciated help and advice from the CMSY working group, notably Rainer Froese (GEOMAR, Kiel, Germany), Athanassios Tsikliras (Aristotle University of Thessaloniki, Greece), Giuseppe Scarcella (CNR, Verona, Italy), and Nazli Demirel (Department of Marine Biology, Istanbul University, Istanbul, Turkey). We also wish to thank all collaborators who participated in the country reviews, which are listed in Appendix E. Finally, in the over 20 years of its operation, the *Sea Around Us* benefitted from the support of the David and Lucille Packard Foundation, Marisla Foundation, MAVA Foundation, Oak Foundation, Oceana, Paul M. Angell Family Foundation, Pew Charitable Trusts, and RARE, and recently from the generous support of the Minderoo Foundation.

References

Abrenica B.T., Mesa S.V., Lanzuela N.S.B., Paran J., Dela Cruz D.M. 2019. Stock assessment of shortfin scad (*Decapterus macrosoma*, Bleeker 1851) in Visayan Sea sub-FMA 11, Central Philippines using CMSY method. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.

Alcantara M.T. and Amigo M.F. 2019. Estimating the status of *Photopectoralis bindus* (Orangefin ponyfish) in Fisheries Management Area 8, Philippines. Presentation to the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.

Alder, J., and U.R. Sumaila. 2004. Western Africa: the fish basket of Europe past and present. *The Journal of Environment and Development,* 13(2): 156-178.

Al-Mamun M.A., Mohanta S.J., Mukherjee R. 2017. Estimation of CMSY for Hilsa fish (*Tenualosa ilisha*). *In*: Palomares M.L.D., Froese R. (eds.) Training on the use of CMSY for the assessment of fish stocks in data-poor environments, p. 35-38. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Q-quatics Technical Report No. 2, 58 p.

Anon. 2014. Republic of Palau Household Income and Expenditure Survey. Office of Planning & Statistics, Bureau of Budget & Planning, Ministry of Finance. Ngerulmud, Republic of Palau.

Atta-Mills, J., J. Alder and U.R. Sumaila. 2004. The unmaking of a regional fishing nation: The case of Ghana and West Africa. *Natural Resources Forum,* 28(1): 13-21.

Banerji S.K., Chakraborty D. 1973. On estimation of yield from exploited marine stocks with reference to South East Asia, p. 176–183 *In:* S.Z. Qasim (ed.), Proceedings of the Symposium on Living Resources of the Seas Around India. Central Marine Fisheries Research Institute, Cochin, India.
Barrowman, N.J. and R.A. Myers. 2000. Still more spawner-recruitment curves: the hockey stick and its generalizations. *Canadian Journal of Fisheries and Aquatic Sciences,* 57(4): 665-676. doi.org/10.1139/f99-282.
Bouch, P., C. Minto and D.G. Reid. 2020. Comparative performance of data-poor CMSY and data-moderate SPiCT stock assessment methods when applied to data-rich, real-world stocks. *ICES Journal of Marine Science,* fsaa220. doi.org/10.1093/icesjms/fsaa220.
Candelario M.B., Mesa S.V., Gonzales L.M., Barlas A.A. 2019. *Decapterus macrosoma* (Bleeker 1851) fisheries in Fisheries Management Area 5, Philippines. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.
Casinillo M.M., Alcantara M.T., Pinero K.D. 2019. *Sardinella lemuru* in Bohol Sea: A CMSY analysis. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.
Cecilio M.A.F., Pautong A.A.T., Ignacia D.B., Revillas C.B., Lakibul A.A. 2019. Stock assessment of mackerel scad (*Decapterus macarellus)* and big-eye scad (*Selar crumenophthalmus*) in Fisheries Management Area 3, Philippines. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.
Cheung, W.W.L., V. Lam, J. Sarmiento, K. Kearney, R. Watson and D. Pauly. 2009. Projecting global marine biodiversity impacts under climate change scenarios. *Fish and Fisheries*, 10(3): 235-251.
Cheung, W.W.L., V. Lam, J. Sarmiento, K. Kearney, R. Watson, D. Zeller and D. Pauly. 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. *Global Change Biology*, 16(1): 24-35.
China Fishery Statistical Yearbook. 2018. Fishery Administration of the Ministry of Agriculture. Agricultural Press of China, Beijing.
Costello, C., D. Ovando, R. Hilborn, S.D. Gaines, O. Deschenes and S.E. Lester. 2012. Status and solutions for the world's unassessed fisheries. *Science,* 338(6106): 517-520.
Costello, C., D. Ovando, T. Clavelle, C.K. Strauss, R. Hilborn, M.C. Melnychuk, T.A. Branch, S.D. Gaines, C.S. Szuwalski, R.B. Cabral, D.N. Rader and A. Leland. 2016. Global fishery prospects under contrasting management regimes. *Proceedings of the National Academy of Sciences,* 113(18): 5125-5129.
Coulter, A., T. Cashion, A.M. Cisneros-Montemayor, S. Popov, G. Tsui, F. Le Manach, L. Schiller, M.L. D. D. Palomares, D. Zeller and D. Pauly. 2019. Using harmonized historical catch data to infer the expansion of global tuna fisheries. *Fisheries Research,* doi.org/10.1016/j.fishres.2019.105379.
Cullis-Suzuki, S. and D. Pauly. 2016. Global evaluation of high seas fisheries management. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press. Washington, D.C.
Dash G., Jasmin F., Kavitha M. 2017. Stock status of *Nemipterus japonicus* along the Chennai Coast. *In*: Palomares M.L.D., Froese R. (eds.) Training on the use of CMSY for the assessment of fish stocks in data-poor environments, p. 20-23. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Q-quatics Technical Report No. 2. 58 p.
Derrick, B., D. Zeller, D. Pauly and M.L.D. Palomares. 2019. *Sea Around Us* research protocols: catch reconstructions. *Sea Around Us* Report to the Minderoo Foundation. Vancouver, Canada. 74 p.
Derrick, B., M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). 2020a. Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the *Sea Around Us*: Part I – Africa, Antarctica, Europe and the North Atlantic. Fisheries Centre Research Report 28 (5), 321 p.
Derrick, B., M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). 2020b. *Updating to 2018 the 1950-2010 marine catch reconstructions of the Sea Around Us. Part II: The Americas and Asia-Pacific*. Fisheries Centre Research Report 28(6), 408 p.
Devaraj M., Vivekanandan E. 1999. Marine capture fisheries of India: challenges and opportunities. *Current Science*, 76(3): 314–332.
DFO. 2009. Precautionary Approach available at: https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-eng.htm
DFO. 2018. Sustainability Survey available at: https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/survey-sondage/data-donnees-en.html
Dineshbabu, Sasikumar G., Koya K.M. 2017. CMSY estimate of ribbonfish exploited off Karnataka, India. *In*: Palomares M.L.D., Froese R. (eds.) Training on the use of CMSY for the assessment of fish stocks in data-

poor environments, p. 43-45. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Q-quatics Technical Report No. 2. 58 p.
FAO. 2018. *The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals*. Food and Agriculture Organization of the United Nations (FAO), Rome. 209 p.
FAO. 2020. *The State of World Fisheries and Aquaculture 2020 - Meeting the sustainable development goals*. Food and Agriculture Organization of the United Nations (FAO), Rome. 244 p.
Fisheries New Zealand. 2020. Fisheries Assessment Plenary, May 2020: stock assessments and stock status. Compiled by the Fisheries Science and Information Group, Fisheries New Zealand, Wellington, New Zealand. Volume 1. 746 p.
Froese, R., H. Winker, G. Coro, M.L.D. Palomares, A.C. Tsikliras, D. Dimarchopoulou, K. Touloumis, N. Demirel, G.M.S. Vianna, G. Scarcella, R. Schijns, C. Liang and D. Pauly. Catch time series as the basis for fish stock assessments: the CMSY++ method. [*manuscript*]
Froese, R., H. Winker, G. Coro, N. Demirel, A.C. Tsikliras, D. Dimarchopoulou, G. Scarcella, W.N. Probst, M. Dureuil and D. Pauly. 2018. A new approach for estimating stock status from length-frequency data. *ICES Journal of Marine Science,* 75(6): 2005-2015. doi.org/10.1093/icesjms/fsy078.
Froese, R., H. Winker, G. Coro, N. Demirel, A.C. Tsikliras, D. Dimarchopoulou, G. Scarcella, W.N. Probst, M. Dureuil and D. Pauly. 2020. Estimating stock status from relative abundance and resilience. *ICES Journal of Marine Science*, 77(2): 527-538. doi:10.1093/icesjms/fsz230
Froese, R., N. Demirel, G. Coro, K.M. Kleisner and H. Winker. 2017. Estimating fisheries reference points from catch and resilience. *Fish and Fisheries,* 18(3): 506-526. doi.org/10.1111/faf.12190.
Gaerlan R.S.P., Laroco M.A., Yutuc R.V., Mendoza R.A., Parido L.D., Dicdiquin N.R., Marjes M. (2019) Stock assessment of small pelagic species (*Decapterus macarellus, Selar crumenophthalmus* and *Sardinella gibbosa*) in Fisheries Management Area 6, Philippines. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.
Ganga U., Rajesh K.M., Vivekanand B. 2017. CMSY for stock assessment of the Indian oil sardine. *In*: Palomares M.L.D., Froese R. (eds.) Training on the use of CMSY for the assessment of fish stocks in data-poor environments, p. 27-30. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Q-quatics Technical Report No. 2. 58 p.
Garibaldi, L. 2012. The FAO global capture production database: A six-decade effort to catch the trend. *Marine Policy*, 36(3): 760-768.
ICES. n.d. a. Who We Are. Available at ICES website: https://www.ices.dk/about-ICES/who-we-are/Pages/Who-we-are.aspx
ICES. n.d. b. Member countries. Available at ICES website: https://www.ices.dk/about-ICES/who-we-are/Pages/Member-Countries.aspx
ICES. n.d. c. Stock Assessment Graphs. Available at ICES website: https://standardgraphs.ices.dk/stockList.aspx
ICES. n.d. d. Dataset Collections: Catch Statistics. Available at ICES website: https://www.ices.dk/data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx
ICES. 2012. Report of the ICES Advisory Committee 2012. ICES Advice, 2012. Book 1. 156 p. doi.org/10.17895/ices.pub.5467
ICES. 2014. Report of the workshop on the development of quantitative assessment methodologies based on life-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE IV), 27-31 October 2014, Lisbon, Portugal. (Copenhagen: ICES CM 2014/ACOM:54).
ICES. 2015. Report of the Fifth Workshop on the development of quantitative assessment methodologies based on life-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE V), 5-9 October 2015, Lisbon, Portugal. (Copenhagen: ICES CM 2015/ACOM:56).
ICES. 2020. Definition and rationale for ICES ecoregions. Report of the ICES Advisory Committee, 2020. ICES Advice 2020, Section 1.4. doi.org/10.17895/ices.advice.6014.
Ignacio D.B., Revillas C.B., Lakibul A.A. 2019. Stock assessment of *Sardinella lemuru* in Fisheries Management Area 4, Philippines, using CMSY. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.
Ju, P., Chen, M., Tian, Y., Zhao, Y., Yang, S. and Xiao, J., 2020b. Stock status estimating of 5 shark species in the waters around Taiwan using a length-based Bayesian biomass estimation (LBB) method. *Frontiers in Marine Science,* 7, 632, https://doi:10.3389/fmars.2020.00632.
Ju, P., Tian, Y., Chen, M., Yang, S., Liu, Y., Xing, Q. and Sun, P. 2020a. Evaluating Stock Status of 16 Commercial Fish Species in the Coastal and Offshore Waters of Taiwan Using the CMSY and BSM Methods. *Frontiers in Marine Science*, 7, 618, https://doi.org/10.3389/fmars.2020.00618.

Kell, L.T, S. Sharma and H. Winker. 2020. Evaluation of data-poor approaches for evaluating stock status and trends: self-testing using biomass-based assessment models. *Collective Volumes of Scientific Papers, ICCAT*, 77(4): 84-95.
Kelleher, K. 2005. Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper. No. 470. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. 131 p.
Khatibzadeh, S., M. Saheb Kashaf, R, Micha, S. Fahimi, P. Shi, I. Elmadfa, S. Kalantarian, P. Wirojratana, M. Ezzati, J. Powles and D. Mozaffarian. 2016. A global database of food and nutrient consumption. *Bulletin of the World Health Organization*, 94(12): 931-934.
Kizhakudan S.J., Menon M., Najmudeen T.M. (2017) Report on the analysis of *Saurida undosquamis* using CMSY/BSM. *In*: Palomares M.L.D., Froese R. (eds.) Training on the use of CMSY for the assessment of fish stocks in data-poor environments, p. 31-34. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Q-quatics Technical Report No. 2. 58 p.
Kleisner, K.M., C. Brennan, A. Garland, S. Lingard, S. Tracey, P. Sahlqvist, A. Tsolos, D. Pauly and D. Zeller. 2015. Australia: Reconstructing estimates of total fisheries removal, 1950-2010. Fisheries Centre Working Paper #2015-02, 26 p.
Kroodsma, D.A., J. Mayorga, T. Hochberg, N.A. Miller, K. Boerder, F. Ferretti, A. Wilson, B. Bergman, T.D. White, B.A. Block, P. Woods, B. Sullivan, C. Costello and B. Worm. 2018. Tracking the global footprint of fisheries. *Science*, 359(6378): 904-908. doi.org/10.1126/science.aao5646.
Lam, V.W.Y., A. Tavakolie, D. Zeller and D. Pauly. 2016. The *Sea Around Us* catch database and its spatial expression, p. 59-67. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press. Washington, D.C.
Le Manach, F., P. Chavance, A.M. Cisneros-Montemayor, A. Lindop, A. Padilla, L. Schiller, D. Zeller and D. Pauly. 2016. Global catches of large pelagic fishes, with emphasis on the High Seas, p. 34-45. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press. Washington, D.C.
Liang, C., Xian, W., Liu, S. and Pauly, D., 2020a. Assessments of 14 exploited fish and invertebrate stocks in Chinese waters using the LBB method. *Frontiers in Marine Science*, 7, 314, https://doi.org/10.3389/fmars.2020.00314.
Liang, C., Xian, W. and Pauly, D., 2020b. Assessments of 15 exploited fish stocks in Chinese, South Korean and Japanese waters using the CMSY and BSM methods. *Frontiers in Marine Science*, 7, 623, https://doi.org/10.3389/fmars.2020.00623.
Martell, S. and R. Froese. 2013. A simple method for estimating MSY from catch and resilience. *Fish and Fisheries*, 14(4): 504-514.
Mesa S.V., Lanzuela N.S.B., Abrenica B.T., Dela Cruz D.M., Baltar J.P., Paran J.S. 2019. Assessing the stock status of *Sardinella gibbosa* (Bleeker 1849) from trawl fishery of Visayan Sea: a CMSY approach. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.
Mohamed KS, Sathianandan TV, Vivekanandan E, Kuriakose S, Ganga U, Pillai SL, et al. 2021. Application of biological and fisheries attributes to assess the vulnerability and resilience of tropical marine fish species. *PLoS ONE* 16(8): e0255879. https://doi.org/10.1371/journal.pone.0255879
Mohan Joseph M., Jayaprakash A.A. (Editors) 2003. *Status of exploited marine fishery resources of India*. Central Marine Fisheries Research Institute, Cochin, India, 308 p.
Musick, J.A. 1999. Criteria to define extinction risk in marine fishes. *Fisheries*, 24(12): 6-14.
Musick, J.A., S.A. Berkeley, G.M. Cailliet, M. Camhi, G. Huntsman, M. Nammack and M.L. Warren Jr. 2000. Protection of marine fish stocks at risk of extinction. *Fisheries*, 25(11): 6-8.
Noël, S.-L. 2020. Semi-automation procedure for catch reconstruction forward carry, p. 15-20. *In*: B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us: Part I – Africa, Antarctica, Europe and the North Atlantic.* Fisheries Centre Research Report 28 (5).
Ota, Y. 2006. Custom and fishing: Cultural meaning and social relations of Pacific fishing, Republic of Palau, Micronesia. PhD thesis, University College of London, London, UK.
Palomares M.L.D., Froese R. (Editors). 2017. Training on the use of CMSY for the assessment of fish stocks in data-poor environments. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Q-quatics Technical Report No. 2. Bay, Laguna, Philippines. p. 58.
Palomares M.L.D., Pauly D. 2014. Philippine Marine Fisheries Catches: A Bottom up Reconstruction, 1950 to 2010. Fisheries Centre Research Report 22, Vancouver, BC: Fisheries Centre, University of British Columbia.

Palomares, M.L.D., W.W.L. Cheung, V. Lam and D. Pauly. 2016. The distribution of exploited marine biodiversity, p. 46-58. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press. Washington, D.C.

Palomares, M.L.D., R. Froese, B. Derrick, S.-L. Noël, G. Tsui, J. Woroniak and D. Pauly. 2018. A preliminary global assessment of the status of exploited marine fish and invertebrate populations. A report prepared by the *Sea Around Us* for OCEANA. University of British Columbia, Vancouver, 64 p.

Palomares, M.L.D., M. Khalfallah, J. Woroniak and D. Pauly (eds.). 2020a. Assessments of marine fisheries resources in West Africa with emphasis on small pelagics. Fisheries Centre Research Report, 28(4), 108 p.

Palomares MLD, Khalfallah M, Woroniak J and Pauly D (Editors). 2020b. Assessment of 14 species of small pelagic fish caught along the coast of Northwest African countries. p. 69-96 In: MLD Palomares, M Khalfallah, J Woroniak and D Pauly D (eds.). Assessments of marine fisheries resources in West Africa with emphasis on small pelagics, Fisheries Centre Research Report 28(4), Institute for the Oceans and Fisheries, University of British Columbia.

Pauly, D. 1998. Rationale for reconstructing catch time series. *EC Fisheries Cooperation Bulletin*, 11(2): 4-10.

Pauly, D. 2007. The *Sea Around Us* Project: Documenting and communicating global fisheries impacts on marine ecosystems. *AMBIO: a Journal of the Human Environment,* 36(4): 290-295.

Pauly, D. 2013. Fisheries: Does catch reflect abundance? Yes, it is a crucial signal. *Nature*, 494(7437): 303-306.

Pauly, D. and R. Froese. 2020. MSY needs no epitaph- but it was abused. *ICES Journal of marine Science*; doi:10.1093/icesjms/fsaa224.

Pauly, D. and C. Liang. 2019. The fisheries of the South China Sea: Major trends since 1950. *Marine Policy,* 121. doi.org/10.1016/j.marpol.2019.103584.

Pauly, D. and D. Zeller. 2016a. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. *Nature Communications*, 7(10244). doi.org/10.1038/ncomms10244.

Pauly, D. and D. Zeller. 2016b. *Global Atlas of Marine Fisheries: A critical appraisal of catches and ecosystem impacts*. Island Press, Washington D.C.

Pauly, D. and F. Le Manach. 2015. Tentative adjustments of China's marine fisheries catches (1950-2010). Fisheries Centre Working Paper #2015-28*,* 16 p.

Pauly, D., C. Liang and W. Xian. 2021. Editorial: Status of Fisheries in East Asia. *Frontiers in Marine Science*, doi: 10.3389/fmars.2021.787217

Pauly, D., V. Christensen, S. Guénette, T.J. Pitcher, U.R. Sumaila, C.J. Walters, R. Watson, R. and D. Zeller. 2002. Towards sustainability in world fisheries. *Nature,* 418(6898): 689-695.

Pauly, D., J. Alder, S. Booth, W.W.L. Cheung, V. Christensen, C. Close, U.R. Sumaila, W. Swartz, A. Tavakolie, R. Watson, L. Wood and D. Zeller. 2008. Fisheries in Large Marine Ecosystems: Descriptions and Diagnoses. p. 23-40. *In*: K. Sherman and G. Hempel (eds.) *The UNEP Large Marine Ecosystem Report: A Perspective on Changing Conditions in LMEs of the World's Regional Seas*. Nairobi, Kenya, UNEP Regional Seas Reports and Studies No. 182.

Pew Charitable Trusts. 2012. FAQ: What is a Regional Fishery Management Organization? Available at: https://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2012/02/23/faq-what-is-a-regional-fishery-management-organization

Pons, M., J.M. Cope and L.T. Kell. 2020. Comparing performance of catch-based and length-based stock assessment methods in data-limited fisheries. *Canadian Journal of Fisheries and Aquatic Sciences*, 77(6): 1026-1037. doi.org/10.1139/cjfas-2019-0276.

Ramos M.H., Candelario M.B., Mesa S.V., Amican C.N., Dicdiquin P.J.J.M., Gonzales L.M., Barlas A.A., Dela Cruz D.M. 2019. Assessing the stock status of Bali sardine (*Sardinella lemuru,* Bleeker 1853) from commercial fishery in the Fisheries Management Area 12, Philippines through CMSY approach. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.

Ren, Q.Q. and Liu, M., 2020. Assessing northwest Pacific fishery stocks using two new methods: the Monte Carlo catch-MSY (CMSY) and the Bayesian Schaefer Model (BSM). *Frontiers in Marine Science*, 7, 430, https://doi.org/10.3389/fmars.2020.00430.

Ricard, D., C. Minto, O.P. Jensen, and J.K. Baum. 2012. Evaluating the knowledge base and status of commercially exploited marine species with the RAM Legacy Stock Assessment Database. *Fish and Fisheries*, 13(4): 380-398.

Rosenberg, A.A., M.J. Fogarty, A.B. Cooper, M. Dickey-Collas, E.A. Fulton, N.L. Gutiérrez, K.J.W. Hyde, K. Kleisner, T. Kristiansen, C. Longo, C. Minte-Vera, C. Minto, I. Mosqueira, G. Chato Osio, D. Ovando, E.R. Selig, J.T. Thorson and Y. Ye. 2014. Developing new approaches to global stock status assessment and fishery production potential of the seas. *FAO Fisheries and Aquaculture Circular No. 1086*. Rome, FAO. 175 p.

Sala, E., J. Mayorga, C. Costello, D. Kroodsma, M.L.D. Palomares, D. Pauly, U.R. Sumaila and D. Zeller. 2018. The economics of fishing the high seas. *Science Advances,* 4, eaat2504. doi.org/10.1126/sciadv.aat2504

Sathianandan T.V., Kuriakose S., Mini K.G., Varghese E. 2017. Use of CMSY and BSM for the assessment of Indian mackerel, *Rastrelliger kanagurta* along the South Kerala coast. In: Palomares M.L.D., Froese R. (eds.) Training on the use of CMSY for the assessment of fish stocks in data-poor environments, p. 24-26. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Qquatics Technical Report No. 2. 58 p

Sathianandan, T. V., Mohamed, K. S., Jayasankar, J., Kuriakose, S., Mini, K. G., Varghese, E., Zacharia, P. U., Kaladharan, P., Najmudeen, T.M., Koya, M. K., Sasikumar, G., Bharti, V., Rohit, P., Maheswarudu, G., Sindhu, K. A., Sreepriya, V., Alphonsa, J., and Deepthi, A. (2021) Status of Indian marine fish stocks: modelling stock biomass dynamics in multigear fisheries. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsab076

Schaefer, M.B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. *Bulletin of the Inter-American Tropical Tuna Commission*, 1: 27-56.

Schaefer, M.B. 1957. A study of the dynamics of populations of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. *Bulletin of the Inter-American Tropical Tuna Commission,* 2: 227-268.

Sherman, K. and A.M. Duda. 1999. Large Marine Ecosystems: An emerging paradigm for fishery sustainability. *Fisheries*, 24(12): 15-26.

Schijns, R., Froese, R., Hutchings, J., & Pauly, D. 2021. Five centuries of cod catches in Eastern Canada. *ICES Journal of Marine Science*, doi:10.1093/icesjms/fsab153.

Schijns, R. and Pauly, D. 2021. Management implications of shifting baselines in fish stock assessments. *Fisheries Management and Ecology*. https://doi.org/10.1111/fme.12511.

Smith, N.S. and Zeller, D. 2016. Unreported catch and tourist demand on local fisheries of small island states: the case of The Bahamas 1950-2010. *Fishery Bulletin,* 114(4): 117-131.

Spalding, M.D., H.E. Fox, G.R. Allen, N. Davidson, Z.A. Ferdaña, M. Finlayson, B.S. Halpern, M.A. Jorge, A. Lombana, S.A. Lourie, K.D. Martin, E. McManus, J. Molnar, C.A. Recchia and J. Robertson. 2007. Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. *Bioscience,* 57(7): 573-583. doi.org/10.1641/b570707.

Srinath M., Kuriakose S., Ammini P.L., Prasad C.J., Ramani K., Beena, M.R. 2006. Marine fish landings in India, 1985–2004. CMFRI Special Publication 89, Central Marine Fisheries Research Institute, Cochin, India, 161 pp.

Tsui, G., B. Derrick, S. de Leon, G. Parducho, S. Popov, S.-L. Noël and C. Ik Zhang. 2021. Countries of the northwest Pacific: Updating catch reconstructions to 2018. *In*: B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us. Part II: The Americas and Asia-Pacific.* Fisheries Centre Research Report 28 [in press]

Venema, S.C., J. Möller-Christensen and D. Pauly. 1988. Training in tropical fish stock assessment: a narrative of experience, p. 1-15. *In:* S.C. Venema, J. Möller-Christensen and D. Pauly (eds) in Contributions to Tropical Fisheries Biology: Papers by the Participants of FAO/DANIDA Follow-Up Training Courses. Rome: FAO Fisheries Report No. 389.

Villarao M.C., Ramos M.H., Lanzuela N.S.B., Gumiran E.F., Baltar J.E.P., Parido L.d.V., Dicdiquin P.J.J.M., Noynay C.V. 2019. Stock assessment of largehead hairtail (*Trichiurus lepturus*, Linnaeus 1758) in Fisheries Management Area 1, Northeastern Philippines. Presented at the Workshop on the Use of the CMSY Tool for the Assessment of Philippine Stocks, 4-8 March 2019, Quezon City, Philippines.

Vivekanandan E., Jayasankar J., Pillai S.L. 2017. CMSY estimate for yellowfin tuna of Indian Ocean. *In*: Palomares M.L.D., Froese R. (eds.) Training on the use of CMSY for the assessment of fish stocks in data-poor environments, p. 39-42. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Q-quatics Technical Report No. 2, 58 p.

Wang, X., He, Y., Du, F., Liu, M., Bei, W., Cai, Y. and Qiu, Y., 2021. Using LBB Tools to Assess Miter Squid Stock in the Northeastern South China Sea. *Frontiers in Marine Science*, 7, 518627. doi: 10.3389/fmars.2020.518627.

Wang, Y., Liang, C., Wang, Y., Xian, W. and Palomares, M.L., 2020b. Stock Status Assessments for 12 Exploited Fishery Species in the Tsushima Warm Current Region, Southwest Japan and East China, Using the CMSY and BSM Methods. *Frontiers in Marine Science*, 7, 640, doi: 10.3389/fmars.2020.00640.

Wang, Y., Wang, Y., Liang, C., Zhang, H. and Xian, W. 2020c. Assessment of 12 fish species in the northwest Pacific using the CMSY and BSM methods. *Frontiers in Marine Science*, 7, 616, https://doi.org/10.3389/fmars.2020.00616.

Wang, Y., Wang, Y., Liu, S., Liang, C., Zhang, H. and Xian, W. 2020a. Stock assessment using LBB method for eight fish species from the Bohai and Yellow Seas. *Frontiers in Marine Science*, 7, 164. doi: 10.3389/fmars.2020.00164.

Wass, R.C. 1980. The shoreline fishery of American Samoa: past and present, p. 51-83 In: J.L. Munro (ed.) Marine and coastal processes in the Pacific: ecological aspects of coastal zone management. Papers presented at a UNESCO seminar held at Motupore Island Research Centre, University of Papua New Guinea and UNESCO, Jakarta Pusat.

Watson, R. and D. Pauly. 2001. Systematic distortions in world fisheries catch trends. *Nature*, 414(6863): 534-536.

Watson, R., W.W.L. Cheung, J. Anticamara, R.U. Sumaila, D. Zeller and D. Pauly. 2013. Global marine yield halved as fishing intensity redoubles. *Fish and Fisheries,* 14(4): 493-503.

Winker, H. and Sherley, R. B. 2019. JARA: 'Just Another Red-List Assessment'. *BioRxiv*, 672899. doi.org/10.1101/672899

Zeller, D. and D. Pauly. 2018. The 'presentist bias' in time-series data: implications for fisheries science and policy. *Marine Policy*, 90, 14-19.

Zeller, D., M. Palomares, A. Tavakolie, M. Ang, D. Belhabib, W. Cheung, V. Lam, E. Sy, G. Tsui, K. Zylich and D. Pauly. 2016. Still catching attention: *Sea Around Us* reconstructed global catch data, their spatial expression and public accessibility. *Marine Policy,* 70: 145-152.

Zeller, D., S. Booth, G. Davis and D. Pauly. 2007. Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years. *Fishery Bulletin*, 105(2): 266-277.

Zeller, D., S. Harper, K. Zylich and D. Pauly. 2014. Synthesis of under-reported small-scale fisheries catch in Pacific-island waters. *Coral Reefs,* 34: 25-39. doi.org/10.1007/s00338-014-1219-1

Zeller, D., T. Cashion, M.L.D. Palomares and D. Pauly. 2018. Global marine fisheries discards: a synthesis of reconstructed data. *Fish & Fisheries,* 19(1): 30-39. doi.org/ 10.1111/faf.12233

Zhai, L. and Pauly, D., 2019. Yield-per-Recruit, Utility-per-Recruit, and Relative Biomass of 21 Exploited Fish Species in China's Coastal Seas. *Frontiers in Marine Science*, 6, 724, https://doi.org/10.3389/fmars.2019.00724.

Zhai, L., Liang, C. and Pauly, D., 2020. Assessments of 16 exploited fish stocks in Chinese waters using the CMSY and BSM methods. *Frontiers in Marine Science*, 7, 483993, doi: 10.3389/fmars.2020.483993.

Zhang, L.L., Ren, Q.Q., Liu, M., Xu, Q., Kang, B. and Jiang, X.B., 2020a. Fishery Stock Assessments in the Min River Estuary and Its Adjacent Waters in Southern China Using the Length-Based Bayesian Estimation (LBB) Method. *Frontiers in Marine Science*, 7, 507, https://doi.org/10.3389/fmars.2020.00507

Zhang, S., Wang, Y., Wang, Y., Liang, C. and Xian, W., 2020b. Assessment of 11 exploited fish and invertebrate populations in the Japan Sea using the CMSY and BSM methods. *Frontiers in Marine Science*, 7, 525363, https://doi.org/10.3389/fmars.2020.525363.

Zhou, S., A.E. Punt, A.D.M. Smith, Y. Ye, M. Haddon, C.M. Dichmont and D.C. Smith. 2017. An optimized catch-only assessment method for data poor fisheries. *ICES Journal of Marine Science,* 75(3): 964-976.

APPENDICES

Appendix A: List of publications applying and improving on the CMSY method.

Alemany, J. 2018. Development of a Bayesian Framework for data limited stock assessment methods and management scenarios proposal. Case studies of cuttlefish (*Sepia officinalis)* and pollack *(Pollachius pollachius)*. PhD thesis. Normande University, Caen, France.

Anderson, S.C., A.B. Cooper, O.P. Jensen, C. Minto, J.T. Thorson, J.C. Walsh, J. Afflerbach, M. Dickey-Collas, K.M. Kleisner, C. Longo and G.C. Osio. 2017. Improving estimates of population status and trend with superensemble models. *Fish and Fisheries,* 18(4): 732-741.

Atmaja, S.B. and B. Sadhotomo. 2018. Prediction of biomass of spotted sardine (*Amblygaster sirm)* in the Java Sea. *Indian Fisheries Research Journal,* 12(1): 91-99.

Ba, K. 2020. Assessing the North-west African stock of black hakes (*Merluccius polli* and *Merluccius senegalensis*) using catch-MSY and length-based spawning potential ratio models. UNESCO GRÓ Fisheries Training Programme, Iceland. Final project.

Barman, P.P., E. Karim, M.H. Khatun, M.F. Rahman, M.S. Alam and Q. Liu. 2020. Application of CMSY to estimate biological reference points of Bombay duck (*Harpadon neherus*) from the Bay of Bengal, Bangladesh. *Applied Ecology and Environmental Research,* 18(6): 8023-8034.

Barua, S. 2019. Maximum Sustainable Yield (MSY) estimates for industrial finfish fishery in marine waters of Bangladesh using trawl catch log. *Bangladesh Journal of Fisheries,* 31(2): 313-324.

Brunel, T., R. Coelho, G. Merino, J. Ortiz de Urbina, D. Rosa, C. Santos, H. Murua, P. Bach, S. Saber and D. Macias. 2018. A preliminary stock assessment for the silky shark in the Indian Ocean using a data-limited approach. IOTC-WPEB14-033.

Coro, G. 2017. "Marine Science with Open Science". Presented at the National Research Council of Italy (CNR), Pisa, Italy.

Cortés, E. and Brooks, E. N. 2018. Stock status and reference points for sharks using data-limited methods and life history. *Fish and Fisheries,* 19(6): 1110-1129.

Cruz, R., J.V.M. Santana, C.G. Barreto, C.A. Borda, M.T. Torres, J.C. Gaeta, J.L.S. Da Silva, S.Z.R. Saraiva, I.S.O Salazar and I.H.A Cintra. 2020. Towards the rebuilding of spiny lobster stocks in Brazil: A review. *Crustaceana,* 93(8): 957-983.

Dan, F. 2020a. Assessment of Indian Ocean kawakawa (*Euthynnus affinis*) using data-limited methods. Indian Ocean Tuna Commission. IOTC–2020–WPNT10–15.

Dan, F. 2020b. Assessment of Indian Ocean narrow-barred Spanish mackerel (*Scomberomorus commerson*) using data-limited methods. Indian Ocean Tuna Commission. IOTC–2020–WPNT10–14.

Dan, F. 2020c. Assessment of Indian Ocean longtail tuna (*Thunnus tonggol*) using data-limited methods. Indian Ocean Tuna Commission. IOTC–2020–WPNT10–13.

Daskalov, G.M., N. Demirel, A. Ulman, Y. Georgieva and M. Zengin. 2020. Stock dynamics and predator–prey effects of Atlantic bonito and bluefish as top predators in the Black Sea. *ICES Journal of Marine Science,* 77(7-8): 2995-3005.

de Anda Montañez, J.A., S. Salas-Pino and G. Galindo-Cortes. 2017. Dealing with dynamics and uncertainty of small pelagic fisheries. *Journal of Marine Biology and Oceanography,* 52(1): 51-65.

Demirel, N., M. Zengin and A. Ulman. 2020. First large-scale Eastern Mediterranean and Black Sea stock assessment reveals a dramatic decline. *Frontiers in Marine Science*, 7: 103.

Falsone, F., D. Scannella, M.L. Geraci, V. Gancitano, S. Vitale and F. Fiorentino. 2021. How fishery collapses: The case of *Lepidopus caudatus* (Pisces: Trichiuridae) in the Strait of Sicily (Central Mediterranean). *Frontiers in Marine Science,* 7: 584601. doi.org/10.3389/fmars.2020.584601

FAO. 2017. Assessment of Indian Ocean longtail tuna (*Thunnus tonggol)* using data limited methods. IOTC-WPNT07-15 Rev_1.

FAO. 2017. Assessment of Indian Ocean narrow-barred Spanish mackerel (*Scomberomorus commerson)* using data limited catch-based methods. IOTC-WPNT07-17 Rev_1.

Fisher, E.A., S.N. Evans, C.J. Desfosses, D.J. Johnston, R. Duffy and K.A. Smith. 2020. Ecological risk assessment for the Peel-Harvey estuarine fishery. Department of Primary Industries and Regional Development, Western Australia. 102 p.

Fitzgerald, C.J., K. Delanty and S. Shephard. 2018. Inland fish stock assessment: Applying data-poor methods from marine systems. *Fisheries Management and Ecology,* 25(4), 240-252.

Free, C.M., O.P. Jensen, J. Wiedenmann and J.J. Deroba. 2017. The refined ORCS approach: A catch-based method for estimating stock status and catch limits for data-poor fish stocks. *Fisheries Research,* 193: 60-70.

Froese, R., H. Winker, G. Coro, N. Demirel, A.C. Tsikliras, D. Dimarchopoulou, G. Scarcella, M. Quaas and N. Matz-Lück. 2018. Status and rebuilding of European fisheries. *Marine Policy*, 93:59-170.

Gajardo, P., M. Olivares and H. Ramírez. 2018. Methods for the Sustainable Rebuilding of Overexploited Natural Resources. *Environmental Modelling and Assessment,* 23: 713-727.

Giron-Nava, A., A.F. Johnson, A.M. Cisneros-Montemayor and O. Aburto-Oropeza. 2019. Managing at maximum sustainable yield does not ensure economic well-being for artisanal fishers. *Fish and Fisheries,* 20(2): 214-223.

Harford, W. J., N.A. Dowling, J.D. Prince, F. Hurd, L. Bellquist, J. Likins and J.R. Wilson. 2019. An indicator-based decision framework for the Northern California red abalone fishery. *Ecosphere,* 10(1): e02533.

Hashemi, S.A.R. 2020. Optimized catch of the largehead hairtail (*Trichiurus lepturus*) in the waters of the Oman Sea (Sistan and Baluchestan province). *Utilization and Cultivation of Aquatics*, 8(4):53-62. doi.org/10.22069/japu.2020.16313.1486

Hashemi, S.A., S.A Taghavimotlagh and M. Doustdar. 2020. Estimation of fisheries reference points of the largehead hairtail, *Trichiurus lepturus* (Teleostei: Trichiuridae) in Iranian waters of Persian Gulf and Oman Sea. *Iranian Journal of Ichthyology,* 7(3): 202-208.

Hélias, A. 2019. Data for fish stock assessment obtained from the CMSY algorithm for all global FAO datasets. *Data*, 4(2): 78.

Hélias, A., J. Langlois and P. Fréon. 2018. Fisheries in life cycle assessment: Operational factors for biotic resources depletion. *Fish and Fisheries*, 19(6): 951-963.

Ji, Y., Q. Liu, B. Liao, Q. Zhang and Y. Han. 2019. Estimating biological reference points for largehead hairtail (*Trichiurus lepturus*) fishery in the Yellow Sea and Bohai Sea. *Acta Oceanologica Sinica,* 38(10): 20-26.

Ju, P., Y. Tian, M. Chen, S. Yang, Y. Liu, Q. Xing and P. Sun. 2020. Evaluating stock status of 16 commercial fish species in the coastal and offshore waters of Taiwan using the CMSY and BSM Methods. *Frontiers in Marine Science*, 7(618):1-7.

Kell, L. T., R. Sharma and H. Winker. 2020. Evaluation of data poor approaches for evaluating stock status and trends: self-testing using biomass-based assessment models. *Collective Volumes of Scientific Papers, ICCAT*, 77(4): 84-95.

Liang, C., W. Xian and D. Pauly. 2020. Assessments of 15 exploited fish stocks in Chinese, South Korean and Japanese waters using the CMSY and BSM methods. *Frontiers in Marine Science*, 7(623):1-11. doi.org/10.3389/fmars.2020.00623

Mourato, B. L., H. Winker, F. Carvalho and M. Ortiz. 2018. Stock assessment of Atlantic blue marlin (*Makaira nigricans)* using a Bayesian state-space surplus production model JABBA. *Collective Volumes of Scientific Papers, ICCAT,* 75(5): 1003-1025.

Musinguzi, L., S. Bassa, V. Natugonza, M. Van Steenberge, W. Okello, J. Snoeksand R. Froese. 2020. Assessment of exploited fish species in the Lake Edward system, East Africa. *Journal of Applied Ichthyology,* 2021(00):1–11. doi.org/10.1111/jai.14161

Musinguzi, L., M. Olokotum and V. Natugonza. 2020. Status and targets for rebuilding the three major fish stocks in Lake Victoria. *bioRxiv* (preprint). doi.org/10.1101/2020.10.26.354639

Najmudeen, T.M., P.K. Seetha and P.U. Zacharia. 2019. Stock dynamics of the brushtooth lizardfish *Saurida undosquamis* (Richardson, 1848) from a tropical multispecies fishery in the Southeastern Arabian Sea. *Aquatic Living Resources*, 32: 9.

Palomares, M.L.D., M. Khalfallah, J. Woroniak and D. Pauly (eds.) 2020a. Assessment of 14 species of small pelagic fish caught along the coast of Northwest African countries. Fisheries Centre Research Report 28(4), Institute for the Oceans and Fisheries, University of British Columbia.

Palomares, M.L.D., M. Khalfallah, J. Woroniak and D. Pauly (Editors). 2020b. Assessments of marine fisheries resources in West Africa withemphasis on small pelagics. Fisheries Centre Research Reports 28(4), 108 p.

Parker, D., H. Winker, C. da Silva, Q. Mketsu and S Kerwatch. 2018. South African National Report to the Scientific Committee of the Indian Ocean Tuna Commission, 2018. IOTC-SC21-NR26.

Pons, M. 2018. Stock status and management in tuna fisheries: from data-rich to data-poor. PhD thesis. University of Washington, Washingtion, USA.

Ren, Q. and M. Liu. 2020. Assessing Northwest Pacific fishery Stocks using two new methods: the Monte Carlo Catch-MSY (CMSY) and the Bayesian Schaefer Model (BSM). *Frontiers in Marine Science*, 7(430):1-9. doi.org/10.3389/fmars.2020.00430

Samsul, H. and N. Siti. 2017. Analysis of the potential reserve crab (*Portunus pelagicus)* sustainable district in Pasuruan. *Proceeding Penelitian Dipa Universitas Dr. Soetomo*, 203-211.
Shi, Y., C. Hua, Q. Zhu, S. Huang and H. Feng. 2020. Applying the catch-MSY model to the stock assessment of the northwestern Pacific saury *Cololabis saira*. *Journal of Oceanology and Limnology,* 38(6):1945-1955. doi.org/10.1007/s00343-019-9156-z
Susilowati, I., S. Anggoro and E.Y.A. Gunanto. 2017. Typical analysis for fisheries management: The case for small-scaler of shrimp fishers. *Advanced Science Letters*, 23(8): 7096-7099.
Tsikliras, A.C., K. Touloumis, A. Pardalou, A. Adamidou, I. Keramidas, G.A. Orfanidis, D. Dimarchopoulou and M. Koutrakis. 2021. Status and exploitation of 74 un-assessed demersal fish and invertebrate stocks in the Aegean Sea (Greece) using abundance and resilience. *Frontiers in Marine Science,* 7: 578601.
Varghese, E., T.V. Sathianandan, J. Jayasankar, S. Kuriakose, K.G. Mini and M. Muktha. 2020. Bayesian state-space implementation of Schaefer production model for assessment of stock status for multi-gear fishery. *Journal of the Indian Society of Agricultural Statistics,* 74(1): 33-40.
Vase, V.K., R. Kumar, A.D. Nakhawa, S. Rahangdale, J, Jayasankar, K.M. Koya, D. Divu and P. Rohit. 2020. Fishery and estimation of potential yield of Bombayduck, *Harpadon nehereus* (Hamilton, 1822) along Gujarat coast, India. *Indian Journal of Fisheries,* 67(1), 1-7.
Wang, Y., Y. Wang, C. Liang, H. Zhang and W. Xian. 2020. Assessment of 12 fish species in the Northwest Pacific using the CMSY and BSM Methods. *Frontiers in Marine Science*, 7(616):1-11. doi.org/10.3389/fmars.2020.00616
Wang, Y., C. Liang, Y. Wang, W. Xian and M.L.D. Palomares. 2020. Stock status assessments for 12 exploited fishery species in the Tsushima warm current region, Southwest Japan and East China, using the CMSY and BSM methods. *Frontiers in Marine Science*, 7(640):1-11. doi.org/10.3389/fmars.2020.00640
Weir, L.H. 2017. Determining threat status for data-limited fisheries based on catch-only stock assessment models. Research project. Simon Fraser University, Summit – Institutional Repository.
Winker, H., F. Carvalho, R. Sharma, D. Parker and S. Kerwath. 2017. Initial results for North and South Atlantic shortfin mako (*Isurus oxyrinchus*) stock assessments using the Bayesian surplus production model JABBA and the catch-resilience method CMSY. *Collective Volumes of Scientific Papers, ICCAT,* 74(4): 1836-1866.
Zhai, L., C. Liang and D. Pauly. 2020. Assessments of 16 exploited fish stocks in Chinese waters using the CMSY and BSM methods. *Frontiers in Marine Science*, 7(483993):1-10. doi.org/10.3389/fmars.2020.483993
Zhang, S., Y. Wang, Y. Wang, C. Liang and W. Xian. 2020. Assessment of 11 exploited fish and invertebrate populations in the Japan Sea using the CMSY and BSM methods. *Frontiers in Marine Science*, 7(525363):1-10. doi.org/10.3389/fmars.2020.525363
Zhou, S., A.E. Punt, A.D. Smith, Y. Ye, M. Haddon, C.M. Dichmont and D.C. Smith. 2018. An optimized catch-only assessment method for data poor fisheries. *ICES Journal of Marine Science*, 75(3): 964-976.

Appendix B: List of stock assessments used for RFMO B-prime estimation

Anon. 2014. Report of the 2014 ICCAT East and West Atlantic skipjack stock assessment meeting, Dakar, Senegal. *Collective Volumes of Scientific Papers, ICCAT*. 98 p.

Anon. 2015. Report of the 2015 ICCAT blue shark stock assessment session. Blue Shark Stock Assessment Session, Lisbon, Portugal. *Collective Volumes of Scientific Papers, ICCAT*. 116 p.

Anon. 2016. Report of the 2016 sailfish stock assessment. Sailfish Stock assessment meeting, Miami, USA. *Collective Volumes of Scientific Papers, ICCAT*. 68 p.

Anon. 2017. Report of the 2017 ICCAT albacore species group intersessional meeting (including assessment of Mediterranean albacore), Madrid, Spain. *Collective Volumes of Scientific Papers, ICCAT*. 45 p.

Anon. 2017. Report of the 2017 ICCAT Atlantic swordfish stock assessment session. Atlantic SWO Stock Assessment Meeting, Madrid, Spain. *Collective Volumes of Scientific Papers, ICCAT*. 85 p.

Anon. 2018. Report of the 2018 ICCAT bigeye tuna stock assessment meeting. BET Stock Assessment Meeting, Pasaia, Spain. *Collective Volumes of Scientific Papers, ICCAT*. 92 p.

Anon. 2018. Report on biology, stock status and management of Southern Bluefin Tuna: 2018. Report of the Twenty-Fifth meeting of the CCSBT Scientific Committee. Available at: https://www.ccsbt.org/en/content/latest-stock-assessment.

Anon. 2019. SCRS Report. *Collective Volumes of Scientific Papers, ICCAT*. 152-163 p. Available at: https://www.iccat.int/Documents/SCRS/ExecSum/SAI_ENG.pdf.

Clarke, S., A. Langley, C. Lennert-Cody, A. Aires-da-Silva and M. Mark. 2018. Pacific-wide silky shark (*Carcharhinus falciformis*) stock status assessment. WCPFC-SC14-2018/SA-WP-08.

Ducharme-Barth, N., G. Pilling and J. Hampton, J. 2019. Stock assessment of SW Pacific striped marlin in the WCPO. Scientific Committee Fifteenth Regular Session, Pohnpei, Federated States of Micronesia. WCPFC-SC15-2019/SA-WP-07.

Hinton, M.G. and M.N. Maunde. 2011. Status of swordfish in the Eastern Pacific Ocean in 2010 and outlook for the future. IATTC Scientific Advisory Committee Second Meeting, La Jolla, California. 33 p.

IOTC Secretariat. 2013. Stock assessment of three billfish species in Indian ocean, blue, black and striped marlin using stock reduction methods. IOTC–2013–WPB11–28_Rev1. 23 p.

IOTC Secretariat. 2015. Assessment of Indian Ocean kawakawa (*Euthynnus affinis*) using data poor catch-based methods. . IOTC–2015–WPNT05–21. p.

IOTC Secretariat. 2015. Assessment of Indian Ocean narrow-barred Spanish mackerel (*Scomberomorus commerson*) using data poor catch-based methods. IOTC–2015–WPNT05–23. 23 p.

IOTC Secretariat. 2017. Status of the Indian Ocean skipjack tuna (SKJ: *Katsuwonus pelamis*) resource. Executive summary - Skipjack tuna. Available at: https://www.iotc.org/node/3379

IOTC Secretariat. 2017. Supporting Information. Swordfish (*Xiphias gladius*). 13 p. Available at: https://www.iotc.org/node/3379

IOTC Secretariat. 2018. Status of the Indian Ocean albacore (ALB: *Thunnus alalunga*) resource. Executive summary - Albacore. Available at: https://www.iotc.org/node/3379

IOTC Secretariat. 2018. Status of the Indian Ocean black marlin (BLM: *Makaira indica*) resource. Executive summary - Black marlin. Available at: https://www.iotc.org/node/3379

IOTC Secretariat. 2018. Status of the Indian Ocean blue marlin (BUM: *Makaira nigricans*) resource. Executive summary - Blue marlin. Available at: https://www.iotc.org/node/3379

IOTC Secretariat. 2018. Status of the Indian Ocean blue shark (BSH: *Prionace glauca*). Executive summary - Blue shark. Available at: https://www.iotc.org/node/3379.

IOTC Secretariat. 2018. Status of the Indian Ocean yellowfin tuna (YFT: *Thunnus albacares*) resource. Executive summary - Yellowfin tuna. Available at: https://www.iotc.org/node/3379

IOTC Secretariat. 2019. Assessment of Indian Ocean Indo-Pacific Sailfish (*Istiophorus platypterus*) using catch-only methods. IOTC–2019–WPB–24. 19 p.

IOTC Secretariat. 2019. Status of the Indian Ocean bigeye tuna (BET: *Thunnus obesus*) resource. Executive summary - Bigeye tuna. IOTC-2019-SC22-ES02. Available at: https://www.iotc.org/node/3379

ISC (International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean). 2020. Stock assessment of albacore tuna in the North Pacific Ocean in 2020. Report of the Albacore Working Group. Northern Committee Sixteenth Regular Session, electronic meeting. WCPFC-NC16-2020/IP-03.

ISC (International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean). 2020. Stock assessment of Pacific bluefin tuna in the Pacific Ocean in 2020. Northern Committee Sixteenth Regular Session, electronic meeting. WCPFC-NC16-2020/IP-04.160 p.

ISC Shark Working Group (International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean). 2018. Stock assessment of shortfin mako shark in the North Pacific ocean through 2016. Report of the Shark Working Group. Eighteenth Meeting of the ISC, Yeosu, Republic of Korea. ISC/18/ANNEX/15.

Juan-Jordá, M.J., I. Mosqueira, A.B. Cooper, J. Freire and N.K. Dulvy. 2011. Supporting information. Global population trajectories of tunas and their relatives. *Proceedings of the National Academy of Sciences*, 108(51): 20650-20655.

McKechnie, S., G. Pilling and J. Hampton. 2017. Stock assessment of bigeye tuna in the western and central Pacific Ocean. Scientific Committee Thirteenth Regular Session, Rarotonga, Cook Islands. WCPFC-SC13-2017/SA-WP-05.149 p.

Minte-Vera, C.V., H. Xu and M.N. Maunder. 2019. Status of yellowfin tuna in the Eastern Pacific Ocean in 2018 and outlook for the future. IATTC Scientific Advisory Committee Tenth Meeting, San Diego, California. 12 p.

Sharma, R., Winker, H., Levontin, P., Kell, L., Ovando, D., Palomares, M.L.D., Pinto, C. and Ye Y. 2021, Assessing the potential of catch-only models to inform on the state of global fisheries and the UN's SDGs. Sustainability 13(11): 6101. https://doi.org/10.3390/su13116101

SPRFMO. 2018. Report of jack mackerel stock assessment workshop, Valparaiso, Chile. SPRFMO–2018–SCW6.27 p.

Takeuchi, Y., G. Pilling and J. Hampton. 2017. Stock assessment of swordfish (*Xiphias gladius*) in the southwest Pacific Ocean. Scientific Committee Thirteenth Regular Session, Rarotonga, Cook Islands. WCPFC-SC13-2017/SA-WP-13. 79 p.

Teo, S., E. Garcia Rodriguez and O. Sosa-Nishizaki. 2018. Status of common thresher sharks, *Alopias vulpinus*, along the west coast of North America: updated stock assessment based on alternative life history. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-SWFSC-595. doi.org/10.7289/V5/TM-SWFSC-595. 284 p.

Tremblay-Boyer, L., F. Carvalho, P. Neubauer and G. Pilling. 2019. Stock assessment for oceanic whitetip shark in the Western and Central Pacific Ocean. WCPFC-SC15-2019/SA-WP-06. Report to the WCPFC Scientific Committee Fifteenth Regular Session. 98 p.

Vincent, M.T., N. Ducharme-Barth, P. Hamer, J. Hampton, P. Williams and G. Pilling. 2020. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. Scientific Committee Sixteenth Regular Session, electronic meeting. WCPFC-SC16-2020/SA-WP-04 (Rev.3). 154 p.

Vincent, M.T., G. Pilling and J. Hampton. 2019. Stock assessment of skipjack tuna in the western and central Pacific Ocean. Scientific Committee Fifteenth Regular Session. 148 p.

Wang, S-P. 2015. Stock assessment of striped marlin (*Kajikia audax*) in the Indian Ocean using a sex-specific age-structured integrated approach. IOTC–2015–WPB13–32_Rev1. 15 p.

WCPFC. 2019. North Pacific Striped Marlin (*Kajikia audax*) stock status and management advice. Available at: https://www.wcpfc.int/doc/10/north-pacific-striped-marlin

WCPFC. 2019. Pacific blue marlin (*Makaira nigricans*) stock status and management advice. Available at: https://www.wcpfc.int/doc/11/pacific-blue-marlin

WCPFC Shark Working Group. 2017. Stock assessment and future projections of blue shark in the North Pacific Ocean through 2015. Scientific Committee Thirteenth Regular Session, Rarotonga, Cook Islands. WCPFC-SC13-2017/ SA-WP-10.

Appendix C: Stock assessments used for ICES areas

ICES. 2018. European eel (*Anguilla anguilla*) throughout its natural range. Report of the ICES Advisory Committee, 2018. ICES Advice 2018, ele.2737.nea. doi.org/10.17895/ices.advice.4601.

ICES. 2018. Horse mackerel (*Trachurus trachurus)* in subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k (the Northeast Atlantic). Report of the ICES Advisory Committee, 2018. ICES Advice 2018, hom.27.2a4a5b6a7a-ce-k8, doi.org/10.17895/ices.pub.4535

ICES. 2018. Pollack (*Pollachius pollachius*) in subarea 4 (North Sea) and division 3.a (North Sea, Skagerrak and Kattegat). Report of the ICES Advisory Committee, 2018. ICES Advice 2018, pol.27.3a4, doi.org/10.17895/ices.pub.4457

ICES. 2018. Spurdog (*Squalus acanthias*) in the Northeast Atlantic. Report of the ICES Advisory Committee, 2018. ICES Advice 2018, dgs.27.nea, doi.org/10.17895/ices.pub.4543

ICES. 2019. Anchovy (*Engraulis encrasicolus*) in division 9.a (Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ane.27.9a, doi.org/10.17895/ices.advice.4852

ICES. 2019. Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ank.27.8c9a, doi.org/10.17895/ices.advice.4756

ICES. 2019. Black-bellied anglerfish (*Lophius budegassa)* in subarea 7 and divisions 8.a-b and 8.d(Celtic Seas, Bay of Biscay). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ank.27.78abd, doi.org/10.17895/ices.advice.4755

ICES. 2019. Blackspot seabream (*Pagellus bogaraveo)* in subarea 10 (Azores grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sbr.27.10, doi.org/10.17895/ices.advice.4820

ICES. 2019. Blue ling (*Molva dypterygia*) in subarea 14 and division 5.a (East Greenland and Iceland grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, bli.27.5a14, doi.org/10.17895/ices.advice.4812

ICES. 2019. Blue ling (*Molva dypterygia)* in subareas 1, 2, 8, 9, and 12, and divisions 3.a and 4.a (other areas). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, bli.27.nea, doi.org/10.17895/ices.advice.4813

ICES. 2019. Brill (*Scophthalmus rhombus*) in subarea 4 and divisions 3.a and 7.d-e (North Sea, Skagerrak and Kattegat, English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, bll.27.3a47de, doi.org/10.17895/ices.advice.4858

ICES. 2019. Cod (*Gadus morhua*) in division 5.a (Iceland grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, cod.27.5a, doi.org/10.17895/ices.advice.4735

ICES. 2019. Cod (*Gadus morhua*) in division 6.a (West of Scotland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, cod.27.6a, doi.org/10.17895/ices.advice.4780.

ICES. 2019. Cod (*Gadus morhua*) in division 7.a (Irish Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, cod.27.7a, doi.org/10.17895/ices.advice.4781

ICES. 2019. Cod (*Gadus morhua*) in divisions 7.e–k (western English Channel and southern Celtic Seas). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, cod.27.7e–k, doi.org/10.17895/ices.advice.4782

ICES. 2019. Cod (*Gadus morhua*) in ICES subarea 14 and NAFO division 1F (East Greenland, Southwest Greenland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, cod.2127.1f14, doi.org/10.17895/ices.advice.4734

ICES. 2019. Cod (*Gadus morhua*) in subarea 4, division 7.d, and subdivision 20 (North Sea, eastern English Channel, Skagerrak). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, cod.27.47d20, doi.org/10.17895/ices.advice.5640.

ICES. 2019. Cod (*Gadus morhua*) in subdivisions 22-24, western Baltic stock (western Baltic Sea). Report of the ICES Advisory Committee, 2019, cod.27.22-24, doi.org/10.17895/ices.advice.5587

ICES. 2019. Cod (*Gadus morhua*) in subdivisions 24-32, eastern Baltic stock (eastern Baltic Sea). Report of the ICES Advisory Committee, 2019, cod.27.24-32, doi.org/10.17895/ices.advice.4747

ICES. 2019. Flounder (*Platichthys flesus*) in subarea 4 and division 3.a (North Sea, Skagerrak and Kattegat). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, fle.27.3a4, 10 pp, doi.org/10.17895/ices.advice.4860

ICES. 2019. Flounder (*Platichthys flesus*) in subdivisions 22 and 23 (Belt Seas and the Sound). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, fle.27.2223, doi.org/10.17895/ices.advice.5273

ICES. 2019. Flounder (*Platichthys flesus*) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, fle.27.2425, doi.org/10.17895/ices.advice.5274

ICES. 2019. Four-spot megrim (*Lepidorhombus boscii*) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ldb.27.8c9a, doi.org/10.17895/ices.advice.4762
ICES. 2019. Golden redfish (*Sebastes norvegicus*) in subareas 5, 6, 12, and 14 (Iceland and Faroes grounds, West of Scotland, North of Azores, East of Greenland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, reg.27.561214, doi.org/10.17895/ices.advice.4741
ICES. 2019. Greater silver smelt (*Argentina silus*) in divisions 5.b and 6.a (Faroes grounds and west of Scotland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, aru.27.5b6a, doi.org/10.17895/ices.advice.4810
ICES. 2019. Greater silver smelt (*Argentina silus*) in subarea 14 and division 5.a (East Greenland and Iceland grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, aru.27.5a14, doi.org/10.17895/ices.advice.4809.
ICES. 2019. Greater silver smelt (*Argentina silus*) in subareas 1, 2, and 4, and in division 3.a (Northeast Arctic, North Sea, Skagerrak and Kattegat). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, aru.27.123a4, doi.org/10.17895/ices.advice.4808
ICES. 2019. Greater silver smelt (*Argentina silus*) in subareas 7-10 and 12, and division 6.b (other areas). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, aru.27.6b7-1012, doi.org/10.17895/ices.advice.4811
ICES. 2019. Greenland halibut (*Reinhardtius hippoglossoides*) in subareas 5, 6, 12, and 14 (Iceland and Faroes grounds, West of Scotland, North of Azores, East of Greenland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ghl.27.561214, doi.org/10.17895/ices.advice.4737
ICES. 2019. Haddock (*Melanogrammus aeglefinus)* in division 5.a (Iceland grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, had.27.5a, doi.org/10.17895/ices.advice.4738
ICES. 2019. Haddock (*Melanogrammus aeglefinus*) in division 7.a (Irish Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, had.27.7a, doi.org/10.17895/ices.advice.4784
ICES. 2019. Haddock (*Melanogrammus aeglefinus*) in divisions 7.b-k (southern Celtic Seas and English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, had.27.7b-k, doi.org/10.17895/ices.advice.4785
ICES. 2019. Haddock (*Melanogrammus aeglefinus*) in subarea 4, division 6.a, and subdivision 20 (North Sea, West of Scotland, Skagerrak). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, had.27.46a20, doi.org/10.17895/ices.advice.5637.
ICES. 2019. Haddock (*Melanogrammus aeglefinus)* in subareas 1 and 2 (Northeast Arctic). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, had.27.1-2, doi.org/10.17895/ices.advice.4713
ICES. 2019. Hake (*Merluccius merluccius*) in divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, hke.27.8c9a, doi.org/10.17895/ices.advice.4760
ICES. 2019. Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and divisions 3.a, 8.a–b, and 8.d, Northern stock (Greater North Sea, Celtic Seas, and the northern Bay of Biscay). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, hke.27.3a46-8abd, doi.org/10.17895/ices.advice.4759
ICES. 2019. Herring (*Clupea harengus*) in division 5.a, summer-spawning herring (Iceland grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, her.27.5a, doi.org/10.17895/ices.advice.4736
ICES. 2019. Herring (*Clupea harengus*) in division 7.a North of 52°30'N (Irish Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, her.27.nirs, doi.org/10.17895/ices.advice.4719
ICES. 2019. Herring (*Clupea harengus*) in divisions 6.a and 7.b-c (West of Scotland, West of Ireland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, her.27.6a7bc doi.org/10.17895/ices.advice.4717
ICES. 2019. Herring (*Clupea harengus*) in divisions 7.a South of 52°30'N, 7.g-h, and 7.j-k (Irish Sea, Celtic Sea, and southwest of Ireland). Report of the ICES Advisory Committee, 2019, her.27.irls, doi.org/10.17895/ices.advice.4718
ICES. 2019. Herring (*Clupea harengus*) in subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak and Kattegat, eastern English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, her.27.3a47d, doi.org/10.17895/ices.advice.4716.
ICES. 2019. Herring (*Clupea harengus*) in subdivision 28.1 (Gulf of Riga). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, her.27.28, doi.org/10.17895/ices.advice.4749
ICES. 2019. Herring (*Clupea harengus*) in subdivisions 20-24, spring spawners (Skagerrak, Kattegat, and western Baltic). Report of the ICES Advisory Committee, 2019, her.27.20-24, doi.org/10.17895/ices.advice.4715

ICES. 2019. Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea). Report of the ICES Advisory Committee, 2019, her.27.25-2932, doi.org/10.17895/ices.advice.4748

ICES. 2019. Herring (*Clupea harengus*) in subdivisions 30 and 31 (Gulf of Bothnia). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, her.27.3031, doi.org/10.17895/ices.advice.4750

ICES. 2019. Horse mackerel (*Trachurus trachurus)* in division 9.a (Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, hom.27.9a, doi.org/10.17895/ices.advice.4853

ICES. 2019. Lemon sole (*Microstomus kitt)* in subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, lem.27.3a47d, doi.org/10.17895/ices.advice.4862

ICES. 2019. Ling (*Molva molva*) in division 5.a (Iceland grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, lin.27.5a, doi.org/10.17895/ices.advice.4816

ICES. 2019. Ling (*Molva molva*) in division 5.b (Faroes grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, lin.27.5b, doi.org/10.17895/ices.advice.4817

ICES. 2019. Ling (*Molva molva*) in subareas 1 and 2 (Northeast Arctic). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, lin.27.1-2, doi.org/10.17895/ices.advice.4814

ICES. 2019. Ling (*Molva molva*) in subareas 6-9, 12, and 14, and divisions 3.a and 4.a (Northeast Atlantic and Arctic Ocean). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, lin.27.3a4a6-91214, doi.org/10.17895/ices.advice.4815

ICES. 2019. Megrim (*Lepidorhombus* spp.) in divisions 4.a and 6.a (northern North Sea, West of Scotland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, lez.27.4a6a, doi.org/10.17895/ices.advice.4786

ICES. 2019. Megrim (*Lepidorhombus whiffiagonis*) in divisions 7.b-k, 8.a-b, and 8.d (west and southwest of Ireland, Bay of Biscay). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, meg.27.7bk8abd, doi.org/10.17895/ices.advice.4763

ICES. 2019. Megrim (*Lepidorhombus whiffiagonis*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019 meg.27.8c9a, doi.org/10.17895/ices.advice.4764

ICES. 2019. Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East (Skagerrak and Kattegat and northern North Sea in the Norwegian Deep). Report of the ICES Advisory Committee, 2019. ICES Advice, pra.27.3a4a, doi.org/10.17895/ices.advice.4892

ICES. 2019. Norway lobster (*Nephrops norvegicus)* in division 3.a, functional units 3 and 4 (Skagerrak and Kattegat). Report of the ICES Advisory Committee. ICES Advice 2019, 2019, nep.fu.3-4, doi.org/10.17895/ices.advice.4864

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 4.a, functional unit 7 (northern North Sea, Fladen Ground). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, nep.fu.7, doi.org/10.17895/ices.advice.5639.

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 4.a, functional unit 9 (central North Sea, Moray Firth). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, nep.fu.9, doi.org/10.17895/ices.advice.4868

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 4.b, functional unit 33 (central North Sea, Horn's Reef. Report of the ICES Advisory Committee, 2019. ICES Advice 2019. ICES Advice 2019, nep.fu.33, 7 pp. doi.org/10.17895/ices.advice.5459

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 4.b, functional unit 6 (central North Sea, Farn Deeps). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, nep.fu.6, doi.org/10.17895/ices.advice.5638

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 4.b, functional unit 8 (central North Sea, Firth of Forth). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, nep.fu.8, doi.org/10.17895/ices.advice.5643.

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 8.c, functional unit 25 (southern Bay of Biscay and northern Galicia). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, nep.fu.25, doi.org/10.17895/ices.advice.4768

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 8.c, functional unit 31 (southern Bay of Biscay and Cantabrian Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, nep.fu.31, doi.org/10.17895/ices.advice.4772

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 9.a, functional units 26–27 (Atlantic Iberian waters East, western Galicia, and northern Portugal). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, nep.fu.2627, doi.org/10.17895/ices.advice.4769

ICES. 2019. Norway lobster (*Nephrops norvegicus*) in division 9.a, functional units 28–29 (Atlantic Iberian waters East and southwestern and southern Portugal). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, nep.fu.2829, doi.org/10.17895/ices.advice.4770

ICES. 2019. Norway special request for revised 2019 advice on mackerel (*Scomber scombrus)* in subareas 1–8 and 14, and in division 9.a (the Northeast Atlantic and adjacent waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sr.2019.09, doi.org/10.17895/ices.advice.5252

ICES. 2019. Plaice (*Pleuronectes platessa*) in division 7.a (Irish Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ple.27.7a, doi.org/10.17895/ices.advice.4798

ICES. 2019. Plaice (*Pleuronectes platessa*) in division 7.d (eastern English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ple.27.7d, doi.org/10.17895/ices.advice.4871

ICES. 2019. Plaice (*Pleuronectes platessa*) in division 7.e (western English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ple.27.7e, doi.org/10.17895/ices.advice.4799

ICES. 2019. Plaice (*Pleuronectes platessa*) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ple.27.7fg, doi.org/10.17895/ices.advice.4800

ICES. 2019. Plaice (*Pleuronectes platessa*) in divisions 7.h-k (Celtic Sea South, southwest of Ireland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ple.27.7h-k, doi.org/10.17895/ices.advice.4801

ICES. 2019. Plaice (*Pleuronectes platessa*) in subarea 4 (North Sea) and subdivision 20 (Skagerrak). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ple.27.420, doi.org/10.17895/ices.advice.5644

ICES. 2019. Plaice (*Pleuronectes platessa*) in subarea 8 and division 9.a (Bay of Biscay and Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ple.27.89a, doi.org/10.17895/ices.advice.4773

ICES. 2019. Plaice (*Pleuronectes platessa*) in subdivisions 21–23 (Kattegat, Belt Seas, and the Sound). Report of the ICES Advisory Committee, 2019, ple.27.21-23, doi.org/10.17895/ices.advice.4751

ICES. 2019. Plaice (*Pleuronectes platessa*) in subdivisions 24-32 (Baltic Sea, excluding the Sound and Belt Seas). Report of the ICES Advisory Committee, 2019, ple.27.24-32, doi.org/10.17895/ices.advice.4752

ICES. 2019. Pollack (*Pollachius pollachius*) in subarea 8 and division 9.a (Bay of Biscay and Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, pol.27.89a, doi.org/10.17895/ices.advice.4774

ICES. 2019. Pollack (*Pollachius pollachius*) in subareas 6–7 (Celtic Seas and the English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, pol.27.6.7, doi.org/10.17895/ices.advice.4802

ICES. 2019. Roundnose grenadier (*Coryphaenoides rupestris*) in divisions 10.b and 12.c, and subdivisions 12.a.1, 14.b.1, and 5.a.1 (Oceanic Northeast Atlantic and northern Reykjanes Ridge). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, rng.27.5a10b12ac14b, doi.org/10.17895/ices.advice.4819

ICES. 2019. Roundnose grenadier (*Coryphaenoides rupestris*) in subareas 1, 2, 4, 8, and 9, division14.a, and in subdivisions 14.b.2 and 5.a.2 (Northeast Atlantic and Arctic Ocean). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, rng.27.1245a8914ab, doi.org/10.17895/ices.advice.4818

ICES. 2019. Saithe (*Pollachius virens*) in division 5.a (Iceland grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, pok.27.5a, doi.org/10.17895/ices.advice.4736

ICES. 2019. Saithe (*Pollachius virens*) in subareas 1 and 2 (Northeast Arctic). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, pok.27.1-2, doi.org/10.17895/ices.advice.4714

ICES. 2019. Saithe (*Pollachius virens*) in subareas 4 and 6, and in division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, pok.27.3a46, doi.org/10.17895/ices.advice.4898

ICES. 2019. Salmon (*Salmo salar)* in subdivision 32 (Gulf of Finland). Report of the ICES Advisory Committee, 2019, sal.27.32, doi.org/10.17895/ices.advice.4743

ICES. 2019. Salmon (*Salmo salar*) in subdivisions 22–31 (Baltic Sea, excluding the Gulf of Finland). Report of the ICES Advisory Committee, 2019, ICES Advice 2019, sal.27.22–31, doi.org/10.17895/ices.advice.4742

ICES. 2019. Sandeel (*Ammodytes* spp.) in division 4.a, Sandeel Area 5r (Northern North Sea, Viking and Bergen banks). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.5r, doi.org/10.17895/ices.advice.4724

ICES. 2019. Sandeel (*Ammodytes* spp.) in division 4.a, Sandeel Area 7r (northern North Sea, Shetland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.7r, doi.org/10.17895/ices.advice.4726

ICES. 2019. Sandeel (*Ammodytes* spp.) in divisions 4.a–b and subdivision 20, Sandeel Area 3r (northern and central North Sea, Skagerrak). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.3r, doi.org/10.17895/ices.advice.4722

ICES. 2019. Sandeel (*Ammodytes* spp.) in divisions 4.a–b, Sandeel Area 4 (northern and central North Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.4, doi.org/10.17895/ices.advice.4723

ICES. 2019. Sandeel (*Ammodytes* spp.) in divisions 4.b and 4.c, Sandeel Area 1r (central and southern North Sea, Dogger Bank). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.1r, doi.org/10.17895/ices.advice.4720

ICES. 2019. Sandeel (*Ammodytes* spp.) in divisions 4.b–c and subdivision 20, Sandeel Area 2r (central and southern North Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.2r, doi.org/10.17895/ices.advice.4721

ICES. 2019. Sandeel (*Ammodytes* spp.) in subdivisions 20–22, Sandeel Area 6 (Skagerrak, Kattegat, and Belt Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, san.sa.6, doi.org/10.17895/ices.advice.4725

ICES. 2019. Sea bass (*Dicentrarchus labrax*) in divisions 4.b–c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea). Report of the ICES Advisory Committee, 2019, bss.27.4bc7ad-h, doi.org/10.17895/ices.advice.4779

ICES. 2019. Sea trout (*Salmo trutta*) in subdivisions 22–32 (Baltic Sea). Report of the ICES Advisory Committee, 2019, trs.27.22–32. doi.org/10.17895/ices.advice.4744

ICES. 2019. Seabass (*Dicentrarchus labrax*) in divisions 8.a-b (northern and central Bay of Biscay). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, bss.27.8ab, doi.org/10.17895/ices.advice.4757

ICES. 2019. Seabass (*Dicentrarchus labrax*) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, bss.27.8c9a, doi.org/10.17895/ices.advice.4758

ICES. 2019. Sole (*Solea solea*) in division 7.a (Irish Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sol.27.7a, doi.org/10.17895/ices.advice.4803

ICES. 2019. Sole (*Solea solea*) in division 7.e (western English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sol.27.7e, doi.org/10.17895/ices.advice.4804

ICES. 2019. Sole (*Solea solea*) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sol.27.7fg, doi.org/10.17895/ices.advice.4805

ICES. 2019. Sole (*Solea solea*) in divisions 7.h-k (Celtic Sea South, southwest of Ireland). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sol.27.7h-k, doi.org/10.17895/ices.advice.4806

ICES. 2019. Sole (*Solea solea*) in divisions 8.a–b (northern and central Bay of Biscay). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sol.27.8ab, doi.org/10.17895/ices.advice.4775

ICES. 2019. Sole (*Solea solea*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sol.27.8c9a, doi.org/10.17895/ices.advice.4776

ICES. 2019. Sole (*Solea solea*) in subarea 4 (North Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sol.27.4, doi.org/10.17895/ices.advice.5642

ICES. 2019. Sole (*Solea solea*) in subdivisions 20–24 (Skagerrak and Kattegat, western Baltic Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sol.27.20-24, doi.org/10.17895/ices.advice.4753

ICES. 2019. Sprat (*Sprattus sprattus*) in division 3.a and subarea 4 (Skagerrak, Kattegat, and North Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, spr.27.3a4, doi.org/10.17895/ices.advice.4727

ICES. 2019. Sprat (*Sprattus sprattus*) in divisions 7.d and 7.e (English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, spr.27.7de, doi.org/10.17895/ices.advice.4729

ICES. 2019. Sprat (*Sprattus sprattus*) in subarea 6 and divisions 7.a–c and 7.f–k (West of Scotland, southern Celtic Seas). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, spr.27.67a-cf-k, doi.org/10.17895/ices.advice.4728

ICES. 2019. Sprat (*Sprattus sprattus*) in subdivisions 22–32 (Baltic Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, spr.27.22-32, doi.org/10.17895/ices.advice.4754

ICES. 2019. Striped red mullet (*Mullus surmuletus*) in subarea 4 and divisions 7.d and 3.a (North Sea, eastern English Channel, Skagerrak and Kattegat). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, mur.27.3a47d, doi.org/10.17895/ices.advice.4863

ICES. 2019. Turbot (*Scophthalmus maximus*) in division 3.a (Skagerrak and Kattegat). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, tur.27.3a, doi.org/10.17895/ices.advice.4875

ICES. 2019. Turbot (*Scophthalmus maximus*) in subarea 4 (North Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, tur.27.4, doi.org/10.17895/ices.advice.4876

ICES. 2019. Tusk (*Brosme brosme*) in subarea 14 and division 5.a (East Greenland, and Iceland grounds). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, usk.27.5a14, doi.org/10.17895/ices.advice.4824.

ICES. 2019. Tusk (*Brosme brosme*) in subareas 1 and 2 (Northeast Arctic). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, usk.27.1-2, doi.org/10.17895/ices.advice.4821

ICES. 2019. Tusk (*Brosme brosme*) in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a, and 12.b (Northeast Atlantic). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, usk.27.3a45b6a7-912b, doi.org/10.17895/ices.advice.4823

ICES. 2019. White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, mon.27.8c9a, doi.org/10.17895/ices.advice.4766

ICES. 2019. White anglerfish (*Lophius piscatorius*) in subarea 7 and divisions 8.a–b and 8.d (Celtic Seas, Bay of Biscay). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, mon.27.78abd, doi.org/10.17895/ices.advice.4765

ICES. 2019. Whiting (*Merlangius merlangus*) in division 7.a (Irish Sea). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, whg.27.7a, doi.org/10.17895/ices.advice.5224

ICES. 2019. Whiting (*Merlangius merlangus*) in divisions 7.b–c and 7.e–k (southern Celtic Seas and eastern English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, whg.27.7b–ce–k, doi.org/10.17895/ices.advice.4807

ICES. 2019. Whiting (*Merlangius merlangus*) in subarea 4 and division 7.d (North Sea and eastern English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, whg.27.47d, doi.org/10.17895/ices.advice.4878

ICES. 2019. Witch (*Glyptocephalus cynoglossus*) in subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel). Report of the ICES Advisory Committee, 2019. ICES Advice 2019, wit.27.3a47d, doi.org/10.17895/ices.advice.4879

Appendix D: Marine ecoregion and EEZ pairing used in the *Sea Around Us*

This table provides the area of overlap of an EEZ with an ME. In the Intersect area column, zero values mean that the overlapping area is <1 Km². In such cases and in cases where the intersect area are negligible, the ME is not assigned to that EEZ.

EEZ ID	EEZ name	ME ID	ME	Intersect area Km²	ME area Km²	EEZ area Km²
8	Albania	221	Adriatic Sea	12156	135271	12164
8	Albania	104	Ionian Sea	8	347361	12164
12	Algeria	80	Alboran Sea	20829	84149	131037
12	Algeria	144	Western Mediterranean	110208	757567	131037
16	American Samoa	78	Phoenix/Tokelau/Northern Cook Islands	86034	2539942	404367
16	American Samoa	79	Samoa Islands	318286	849376	404367
16	American Samoa	156	Southern Cook/Austral Islands	0	1742006	404367
16	American Samoa	129	Tonga Islands	1	840051	404367
357	Andaman & Nicobar Isl. (India)	137	Andaman and Nicobar Islands	659574	734098	659575
24	Angola	101	Angolan	393820	393820	493989
24	Angola	102	Gulf of Guinea South	15484	229164	493989
24	Angola	179	Namib	84569	437193	493989
660	Anguilla (UK)	116	Eastern Caribbean	89819	868768	89969
976	Antarctica, 200 nm zone	22	Amundsen/Bellingshausen Sea	1076902	1076902	9243195
976	Antarctica, 200 nm zone	4	Antarctic Peninsula	445949	445949	9243195
976	Antarctica, 200 nm zone	11	East Antarctic Dronning Maud Land	715892	724799	9243195
976	Antarctica, 200 nm zone	12	East Antarctic Enderby Land	233944	233944	9243195
976	Antarctica, 200 nm zone	13	East Antarctic Wilkes Land	2234867	2248790	9243195
976	Antarctica, 200 nm zone	213	Peter the First Island	122812	122812	9243195
976	Antarctica, 200 nm zone	23	Ross Sea	971191	971192	9243195
976	Antarctica, 200 nm zone	28	South Shetland Islands	326374	341593	9243195
976	Antarctica, 200 nm zone	33	Weddell Sea	1353596	1354746	9243195
28	Antigua & Barbuda	116	Eastern Caribbean	110750	868768	111334
32	Argentina	125	Channels and Fjords of Southern Chile	171674	899871	1092595
32	Argentina	198	North Patagonian Gulfs	208483	208480	1092595
32	Argentina	21	Patagonian Shelf	402973	416585	1092595
32	Argentina	130	Rio de la Plata	15962	31666	1092595
32	Argentina	131	Uruguay-Buenos Aires Shelf	293454	400686	1092595
967	Aruba (Netherlands)	143	Greater Antilles	0	1157222	31028
967	Aruba (Netherlands)	127	Southern Caribbean	31027	584596	31028
855	Ascension Isl. (UK)	218	St. Helena and Ascension Islands	441642	886540	441641
36	Australia	109	Arnhem Coast to Gulf of Carpentaria	571768	571787	6333687
36	Australia	5	Banda Sea	41	941189	6333687
36	Australia	110	Bassian	549221	549221	6333687
36	Australia	108	Bonaparte Coast	291040	291172	6333687
36	Australia	6	Cape Howe	286961	286961	6333687
36	Australia	95	Central and Southern Great Barrier Reef	208601	208601	6333687
36	Australia	91	Coral Sea	967629	968505	6333687
36	Australia	147	Exmouth to Broome	710626	710626	6333687
36	Australia	225	Great Australian Bight	326079	326079	6333687

36	Australia	117	Houtman	203931	203931	6333687
36	Australia	224	Leeuwin	605944	605948	6333687
36	Australia	128	Lesser Sunda	38	717561	6333687
36	Australia	66	Manning-Hawkesbury	210319	210319	6333687
36	Australia	133	New Caledonia	250	1252156	6333687
36	Australia	189	Ningaloo	163389	163389	6333687
36	Australia	58	Shark Bay	205872	205872	6333687
36	Australia	27	South Australian Gulfs	205555	205555	6333687
36	Australia	154	Southeast Papua New Guinea	6	209228	6333687
36	Australia	38	Torres Strait Northern Great Barrier Reef	193104	193124	6333687
36	Australia	90	Tweed-Moreton	279695	279696	6333687
36	Australia	36	Western Bassian	353862	353862	6333687
622	Azores Isl. (Portugal)	82	Azores Canaries Madeira	953084	1865442	958740
44	Bahamas	161	Bahamian	597347	923316	618924
44	Bahamas	173	Carolinian	0	370086	618924
44	Bahamas	75	Floridian	1195	229441	618924
44	Bahamas	143	Greater Antilles	18557	1157222	618924
48	Bahrain	136	Arabian (Persian) Gulf	7568	238347	7568
903	Balearic Islands (Spain)	144	Western Mediterranean	129060	757567	129060
50	Bangladesh	53	Northern Bay of Bengal	110891	485565	110970
52	Barbados	116	Eastern Caribbean	183511	868768	184252
52	Barbados	226	Guianan	544	453298	184252
52	Barbados	127	Southern Caribbean	110	584596	184252
56	Belgium	41	North Sea	3479	680979	3479
84	Belize	160	Western Caribbean	34299	242364	34299
204	Benin	16	Gulf of Guinea Central	35253	382239	35253
60	Bermuda (UK)	201	Bermuda	450347	450347	450347
907	Bonaire (Netherlands)	127	Southern Caribbean	12811	584596	12811
70	Bosnia & Herzegovina	221	Adriatic Sea	13	135271	13
74	Bouvet Isl. (Norway)	202	Bouvet Island	441176	441265	441176
76	Brazil (mainland)	118	Amazonia	565109	565120	2411248
76	Brazil (mainland)	52	Eastern Brazil	494956	674995	2411248
76	Brazil (mainland)	226	Guianan	18	453298	2411248
76	Brazil (mainland)	119	Northeastern Brazil	665966	665966	2411248
76	Brazil (mainland)	132	Rio Grande	283141	283176	2411248
76	Brazil (mainland)	86	Southeastern Brazil	391714	391723	2411248
76	Brazil (mainland)	131	Uruguay-Buenos Aires Shelf	1589	400686	2411248
92	British Virgin Isl. (UK)	161	Bahamian	0	923316	81071
92	British Virgin Isl. (UK)	116	Eastern Caribbean	80953	868768	81071
96	Brunei Darussalam	123	Palawan/North Borneo	25350	572946	43056
96	Brunei Darussalam	146	South China Sea Oceanic Islands	17708	1255398	43056
100	Bulgaria	155	Black Sea	34768	460086	34768
116	Cambodia	56	Gulf of Thailand	48589	266482	48589
120	Cameroon	16	Gulf of Guinea Central	14892	382239	14892
924	Canada (Arctic)	45	Baffin Bay - Davis Strait	2104	321290	3049738

924	Canada (Arctic)	47	Beaufort Sea - continental coast and shelf	298809	503059	3049738
924	Canada (Arctic)	46	Beaufort-Amundsen-Viscount Melville-Queen Maud	514609	514609	3049738
924	Canada (Arctic)	63	High Arctic Archipelago	722370	722370	3049738
924	Canada (Arctic)	77	Hudson Complex	1243260	1243260	3049738
924	Canada (Arctic)	64	Lancaster Sound	240195	246108	3049738
924	Canada (Arctic)	69	North Greenland	1531	675764	3049738
924	Canada (Arctic)	59	Northern Labrador	6	447235	3049738
926	Canada (East Coast)	45	Baffin Bay - Davis Strait	319162	321290	2273430
926	Canada (East Coast)	55	Gulf of Maine/Bay of Fundy	60616	198833	2273430
926	Canada (East Coast)	87	Gulf of St. Lawrence - Eastern Scotian Shelf	435237	439219	2273430
926	Canada (East Coast)	77	Hudson Complex	0	1243260	2273430
926	Canada (East Coast)	64	Lancaster Sound	5913	246108	2273430
926	Canada (East Coast)	76	Northern Grand Banks - Southern Labrador	522749	527223	2273430
926	Canada (East Coast)	59	Northern Labrador	446623	447235	2273430
926	Canada (East Coast)	229	Scotian Shelf	269570	269570	2273430
926	Canada (East Coast)	121	Southern Grand Banks - South Newfoundland	211037	337376	2273430
926	Canada (East Coast)	115	West Greenland Shelf	3	764650	2273430
925	Canada (Pacific)	166	North American Pacific Fijordland	318642	478070	451437
925	Canada (Pacific)	142	Oregon, Washington, Vancouver Coast and Shelf	123176	437987	451437
925	Canada (Pacific)	181	Puget Trough/Georgia Basin	9313	15770	451437
723	Canary Isl. (Spain)	82	Azores Canaries Madeira	444667	1865442	444714
723	Canary Isl. (Spain)	81	Saharan Upwelling	47	558772	444714
132	Cape Verde	188	Cape Verde	796551	796555	796624
132	Cape Verde	103	Sahelian Upwelling	0	335699	796624
136	Cayman Isl. (UK)	143	Greater Antilles	118414	1157222	120490
136	Cayman Isl. (UK)	32	Southwestern Caribbean	0	741578	120490
136	Cayman Isl. (UK)	160	Western Caribbean	2076	242364	120490
86	Chagos Archipelago (UK)	114	Chagos	638556	638556	638556
830	Channel Isl. (UK)	85	Celtic Seas	8810	879067	8810
152	Chile (mainland)	10	Araucanian	376291	376291	1955640
152	Chile (mainland)	107	Central Chile	344002	344002	1955640
152	Chile (mainland)	125	Channels and Fjords of Southern Chile	694622	899871	1955640
152	Chile (mainland)	9	Chiloense	278065	278065	1955640
152	Chile (mainland)	111	Humboldtian	262094	691032	1955640
152	Chile (mainland)	21	Patagonian Shelf	30	416585	1955640
156	China	49	East China Sea	376270	686453	2611739
156	China	176	Gulf of Tonkin	143810	289433	2611739
156	China	123	Palawan/North Borneo	79250	572946	2611739
156	China	146	South China Sea Oceanic Islands	1239846	1255398	2611739
156	China	145	South Kuroshio	57129	1461400	2611739
156	China	184	Southern China	281606	283612	2611739
156	China	57	Sunda Shelf/Java Sea	155895	1386854	2611739
156	China	148	Yellow Sea	277923	435845	2611739
162	Christmas Isl. (Australia)	191	Cocos-Keeling/Christmas Island	327992	795233	327993
898	Clipperton Isl. (France)	203	Clipperton	431274	431274	431274

166	Cocos (Keeling) Isl. (Australia)	191	Cocos-Keeling/Christmas Island	467229	795233	467229
927	Colombia (Caribbean)	143	Greater Antilles	7398	1157222	423139
927	Colombia (Caribbean)	127	Southern Caribbean	111499	584596	423139
927	Colombia (Caribbean)	32	Southwestern Caribbean	304248	741578	423139
928	Colombia (Pacific)	232	Cocos Islands	0	335960	326661
928	Colombia (Pacific)	141	Nicoya	5	288802	326661
928	Colombia (Pacific)	180	Panama Bight	326656	525331	326661
174	Comoros Isl.	89	East African Coral Coast	2284	478916	231695
174	Comoros Isl.	182	Seychelles	323	1334015	231695
174	Comoros Isl.	35	Western and Northern Madagascar	228694	1334065	231695
180	Congo (ex-Zaire)	101	Angolan	0	393820	13139
180	Congo (ex-Zaire)	102	Gulf of Guinea South	13139	229164	13139
178	Congo, R. of	102	Gulf of Guinea South	33975	229164	33975
184	Cook Islands	78	Phoenix/Tokelau/Northern Cook Islands	956849	2539942	1960013
184	Cook Islands	79	Samoa Islands	0	849376	1960013
184	Cook Islands	156	Southern Cook/Austral Islands	1003164	1742006	1960013
899	Corsica (France)	144	Western Mediterranean	23539	757567	23539
929	Costa Rica (Caribbean)	32	Southwestern Caribbean	20231	741578	20231
930	Costa Rica (Pacific)	223	Chiapas-Nicaragua	0	376906	545199
930	Costa Rica (Pacific)	232	Cocos Islands	335918	335960	545199
930	Costa Rica (Pacific)	141	Nicoya	209193	288802	545199
384	Côte d'Ivoire	1	Gulf of Guinea Upwelling	169562	343204	169654
384	Côte d'Ivoire	174	Gulf of Guinea West	0	620646	169654
900	Crete (Greece)	105	Aegean Sea	96353	375812	96529
900	Crete (Greece)	106	Levantine Sea	134	421745	96529
900	Crete (Greece)	138	Tunisian Plateau/Gulf of Sidra	47	402162	96529
191	Croatia	221	Adriatic Sea	55920	135271	55920
896	Crozet Isl. (France)	204	Crozet Islands	574541	574713	574542
192	Cuba	161	Bahamian	164	923316	351485
192	Cuba	75	Floridian	330	229441	351485
192	Cuba	143	Greater Antilles	346037	1157222	351485
192	Cuba	122	Southern Gulf of Mexico	12	688764	351485
192	Cuba	160	Western Caribbean	4940	242364	351485
906	Curaçao (Netherlands)	143	Greater Antilles	0	1157222	25599
906	Curaçao (Netherlands)	127	Southern Caribbean	25599	584596	25599
197	Cyprus (North)	106	Levantine Sea	17677	421745	17677
198	Cyprus (South)	105	Aegean Sea	240	375812	80782
198	Cyprus (South)	106	Levantine Sea	80538	421745	80782
931	Denmark (Baltic Sea)	97	Baltic Sea	16564	376537	29369
931	Denmark (Baltic Sea)	41	North Sea	12805	680979	29369
932	Denmark (North Sea)	41	North Sea	75714	680979	75714
154	Desventuradas Isl. (Chile)	209	Juan Fernandez and Desventuradas	449836	952841	449836
262	Djibouti	151	Gulf of Aden	7502	560060	7502
212	Dominica	116	Eastern Caribbean	28599	868768	28599
214	Dominican Republic	161	Bahamian	156028	923316	377748

214	Dominican Republic	116	Eastern Caribbean	0	868768	377748
214	Dominican Republic	143	Greater Antilles	192064	1157222	377748
214	Dominican Republic	127	Southern Caribbean	7888	584596	377748
153	Easter Isl. (Chile)	205	Easter Island	720412	721018	720412
218	Ecuador (mainland)	169	Guayaquil	145078	258565	234767
218	Ecuador (mainland)	180	Panama Bight	89684	525331	234767
933	Egypt (Mediterranean)	105	Aegean Sea	599	375812	170371
933	Egypt (Mediterranean)	106	Levantine Sea	169773	421745	170371
934	Egypt (Red Sea)	30	Northern and Central Red Sea	91527	228824	91527
222	El Salvador	223	Chiapas-Nicaragua	94499	376906	94504
226	Equatorial Guinea	16	Gulf of Guinea Central	53794	382239	302995
226	Equatorial Guinea	206	Gulf of Guinea Islands	249019	417522	302995
226	Equatorial Guinea	102	Gulf of Guinea South	5	229164	302995
111	Eritrea	151	Gulf of Aden	2302	560060	78325
111	Eritrea	31	Southern Red Sea	76023	225930	78325
233	Estonia	97	Baltic Sea	36432	376537	36432
234	Faeroe Isl. (Denmark)	85	Celtic Seas	6651	879067	272210
234	Faeroe Isl. (Denmark)	39	Faroe Plateau	265032	267926	272210
234	Faeroe Isl. (Denmark)	228	North and East Iceland	7	568491	272210
238	Falkland Isl. (UK)	199	Malvinas/Falklands	549981	549981	549974
969	Fernando de Noronha (Brazil)	14	Fernando de Naronha and Atoll das Rocas	363359	363359	363362
242	Fiji	68	Fiji Islands	786034	786024	1280793
242	Fiji	15	Gilbert/Ellis Islands	273906	2396454	1280793
242	Fiji	129	Tonga Islands	0	840051	1280793
242	Fiji	126	Vanuatu	220589	1662460	1280793
246	Finland	97	Baltic Sea	82365	376537	82365
919	France (Atlantic Coast)	85	Celtic Seas	50363	879067	258312
919	France (Atlantic Coast)	41	North Sea	21421	680979	258312
919	France (Atlantic Coast)	84	South European Atlantic Shelf	186190	800447	258312
918	France (Mediterranean)	144	Western Mediterranean	63984	757567	63984
254	French Guiana	226	Guianan	130099	453298	131341
258	French Polynesia	220	Marquesas	749098	749101	4769854
258	French Polynesia	222	Rapa-Pitcairn	465703	1305423	4769854
258	French Polynesia	194	Society Islands	644569	644569	4769854
258	French Polynesia	156	Southern Cook/Austral Islands	738834	1742006	4769854
258	French Polynesia	18	Tuamotus	2169292	2739979	4769854
266	Gabon	16	Gulf of Guinea Central	29153	382239	199897
266	Gabon	206	Gulf of Guinea Islands	3178	417522	199897
266	Gabon	102	Gulf of Guinea South	166525	229164	199897
219	Galapagos Isl. (Ecuador)	73	Eastern Galapagos Islands	390488	390488	835538
219	Galapagos Isl. (Ecuador)	149	Northern Galapagos Islands	213088	213094	835538
219	Galapagos Isl. (Ecuador)	193	Western Galapagos Islands	231964	231959	835538
270	Gambia	188	Cape Verde	4	796555	22906
270	Gambia	103	Sahelian Upwelling	22651	335699	22906
274	Gaza Strip	106	Levantine Sea	2339	421745	2339

268	Georgia	155	Black Sea	22948	460086	22948
278	Germany (Baltic Sea)	97	Baltic Sea	10421	376537	15397
278	Germany (Baltic Sea)	41	North Sea	4976	680979	15397
277	Germany (North Sea)	41	North Sea	41000	680979	41000
288	Ghana	16	Gulf of Guinea Central	56225	382239	226087
288	Ghana	1	Gulf of Guinea Upwelling	169439	343204	226087
972	Glorieuse Islands (France)	35	Western and Northern Madagascar	43138	1334065	43139
300	Greece (without Crete)	221	Adriatic Sea	4	135271	387656
300	Greece (without Crete)	105	Aegean Sea	237108	375812	387656
300	Greece (without Crete)	104	Ionian Sea	150488	347361	387656
300	Greece (without Crete)	106	Levantine Sea	21	421745	387656
300	Greece (without Crete)	138	Tunisian Plateau/Gulf of Sidra	11	402162	387656
304	Greenland (Denmark)	227	East Greenland Shelf	837276	837468	2275652
304	Greenland (Denmark)	69	North Greenland	674233	675764	2275652
304	Greenland (Denmark)	115	West Greenland Shelf	763643	764650	2275652
308	Grenada	116	Eastern Caribbean	25120	868768	25582
308	Grenada	127	Southern Caribbean	462	584596	25582
312	Guadeloupe (France)	116	Eastern Caribbean	90581	868768	90581
316	Guam (USA)	67	East Caroline Islands	16	2462658	207876
316	Guam (USA)	195	Mariana Islands	207875	970769	207876
316	Guam (USA)	186	West Caroline Islands	113	1134134	207876
935	Guatemala (Caribbean)	160	Western Caribbean	1495	242364	1495
936	Guatemala (Pacific)	223	Chiapas-Nicaragua	107560	376906	107582
324	Guinea	174	Gulf of Guinea West	101521	620646	101521
624	Guinea-Bissau	174	Gulf of Guinea West	105841	620646	140456
624	Guinea-Bissau	103	Sahelian Upwelling	34368	335699	140456
328	Guyana	226	Guianan	138170	453298	138434
332	Haiti	161	Bahamian	31	923316	117245
332	Haiti	143	Greater Antilles	117214	1157222	117245
842	Hawaii Main Islands (USA)	207	Hawaii	895895	2917340	895895
488	Hawaii Northwest Islands (USA)	207	Hawaii	1578813	2917340	1578813
334	Heard & McDonald Isl. (Australia)	208	Heard and Macdonald Islands	417015	417222	417040
921	Honduras (Caribbean)	143	Greater Antilles	1	1157222	209546
921	Honduras (Caribbean)	32	Southwestern Caribbean	101980	741578	209546
921	Honduras (Caribbean)	160	Western Caribbean	107567	242364	209546
920	Honduras (Pacific)	223	Chiapas-Nicaragua	770	376906	770
344	Hong Kong (China)	184	Southern China	2008	283612	2008
846	Howland & Baker Isl. (USA)	78	Phoenix/Tokelau/Northern Cook Islands	434922	2539942	434922
352	Iceland	39	Faroe Plateau	2832	267926	795358
352	Iceland	228	North and East Iceland	308633	568491	795358
352	Iceland	40	South and West Iceland	480052	480052	795358
356	India (mainland)	54	Eastern India	420755	420761	1655691
356	India (mainland)	113	Maldives	402806	1318816	1655691
356	India (mainland)	53	Northern Bay of Bengal	116890	485565	1655691
356	India (mainland)	162	South India and Sri Lanka	130501	661444	1655691

356	India (mainland)	175	Western India	546180	640184	1655691
937	Indonesia (Central)	128	Lesser Sunda	0	717561	1002277
937	Indonesia (Central)	230	Malacca Strait	13635	168385	1002277
937	Indonesia (Central)	96	Southern Java	26682	604753	1002277
937	Indonesia (Central)	124	Sulawesi Sea/Makassar Strait	0	740991	1002277
937	Indonesia (Central)	57	Sunda Shelf/Java Sea	961960	1386854	1002277
361	Indonesia (Eastern)	37	Arafura Sea	343193	370338	3598502
361	Indonesia (Eastern)	109	Arnhem Coast to Gulf of Carpentaria	9	571787	3598502
361	Indonesia (Eastern)	5	Banda Sea	938144	941189	3598502
361	Indonesia (Eastern)	153	Bismarck Sea	93	757742	3598502
361	Indonesia (Eastern)	108	Bonaparte Coast	37	291172	3598502
361	Indonesia (Eastern)	163	Eastern Philippines	69304	922014	3598502
361	Indonesia (Eastern)	147	Exmouth to Broome	0	710626	3598502
361	Indonesia (Eastern)	157	Halmahera	254764	254860	3598502
361	Indonesia (Eastern)	128	Lesser Sunda	642392	717561	3598502
361	Indonesia (Eastern)	187	Northeast Sulawesi	69981	69981	3598502
361	Indonesia (Eastern)	123	Palawan/North Borneo	44085	572946	3598502
361	Indonesia (Eastern)	231	Papua	639546	641475	3598502
361	Indonesia (Eastern)	124	Sulawesi Sea/Makassar Strait	596924	740991	3598502
361	Indonesia (Eastern)	57	Sunda Shelf/Java Sea	0	1386854	3598502
361	Indonesia (Eastern)	186	West Caroline Islands	14	1134134	3598502
938	Indonesia (Indian Ocean)	191	Cocos-Keeling/Christmas Island	0	795233	1410214
938	Indonesia (Indian Ocean)	230	Malacca Strait	84925	168385	1410214
938	Indonesia (Indian Ocean)	96	Southern Java	578038	604753	1410214
938	Indonesia (Indian Ocean)	94	Western Sumatra	747253	747253	1410214
922	Iran (Persian Gulf)	136	Arabian (Persian) Gulf	98727	238347	98727
923	Iran (Sea of Oman)	136	Arabian (Persian) Gulf	2003	238347	64475
923	Iran (Sea of Oman)	93	Gulf of Oman	62472	275487	64475
368	Iraq	136	Arabian (Persian) Gulf	1148	238347	1148
372	Ireland	85	Celtic Seas	427735	879067	427734
939	Israel (Mediterranean)	106	Levantine Sea	25805	421745	25807
940	Israel (Red Sea)	30	Northern and Central Red Sea	31	228824	31
380	Italy (mainland)	221	Adriatic Sea	60679	135271	314331
380	Italy (mainland)	104	Ionian Sea	116290	347361	314331
380	Italy (mainland)	144	Western Mediterranean	137362	757567	314331
388	Jamaica	143	Greater Antilles	265059	1157222	286159
388	Jamaica	32	Southwestern Caribbean	21089	741578	286159
579	Jan Mayen Isl. (Norway)	228	North and East Iceland	305230	568491	304996
393	Japan (Daito Islands)	7	Central Kuroshio Current	0	601291	792308
393	Japan (Daito Islands)	168	Ogasawara Islands	0	1261469	792308
393	Japan (Daito Islands)	145	South Kuroshio	792251	1461400	792308
390	Japan (main islands)	7	Central Kuroshio Current	601286	601291	2584333
390	Japan (main islands)	49	East China Sea	295632	686453	2584333
390	Japan (main islands)	70	Northeastern Honshu	277141	277151	2584333
390	Japan (main islands)	168	Ogasawara Islands	175310	1261469	2584333

390	Japan (main islands)	60	Oyashio Current	348269	973047	2584333
390	Japan (main islands)	25	Sea of Japan/East Sea	493627	989381	2584333
390	Japan (main islands)	83	Sea of Okhotsk	124	1236094	2584333
390	Japan (main islands)	145	South Kuroshio	391840	1461400	2584333
971	Japan (Ogasawara Islands)	168	Ogasawara Islands	1082503	1261469	1082628
971	Japan (Ogasawara Islands)	145	South Kuroshio	10	1461400	1082628
845	Jarvis Isl. (USA)	65	Line Islands	324239	1743769	324239
396	Johnston Atoll (USA)	207	Hawaii	442630	2917340	442630
400	Jordan	30	Northern and Central Red Sea	97	228824	97
155	Juan Fernandez Islands (Chile)	209	Juan Fernandez and Desventuradas	503005	952841	502524
404	Kenya	89	East African Coral Coast	111470	478916	162794
404	Kenya	88	Northern Monsoon Current Coast	51324	260802	162794
897	Kerguelen Isl. (France)	210	Kerguelen Islands	567655	567655	567630
555	Kermadec Isl. (New Zealand)	211	Kermadec Island	621762	621797	621785
941	Kiribati (Gilbert Islands)	15	Gilbert/Ellis Islands	1048864	2396454	1050679
941	Kiribati (Gilbert Islands)	19	Marshall Islands	0	2399284	1050679
942	Kiribati (Line Islands)	65	Line Islands	1066997	1743769	1637683
942	Kiribati (Line Islands)	194	Society Islands	0	644569	1637683
942	Kiribati (Line Islands)	18	Tuamotus	570687	2739979	1637683
943	Kiribati (Phoenix Islands)	78	Phoenix/Tokelau/Northern Cook Islands	743053	2539942	743052
974	Korea (North, Sea of Japan)	25	Sea of Japan/East Sea	89058	989381	89058
973	Korea (North, Yellow Sea)	148	Yellow Sea	24841	435845	24845
410	Korea (South)	49	East China Sea	170587	686453	453289
410	Korea (South)	25	Sea of Japan/East Sea	149620	989381	453289
410	Korea (South)	148	Yellow Sea	133082	435845	453289
414	Kuwait	136	Arabian (Persian) Gulf	11162	238347	11162
428	Latvia	97	Baltic Sea	28298	376537	28298
422	Lebanon	106	Levantine Sea	20172	421745	20172
430	Liberia	1	Gulf of Guinea Upwelling	4201	343204	250311
430	Liberia	174	Gulf of Guinea West	246093	620646	250311
434	Libya	105	Aegean Sea	463	375812	363895
434	Libya	104	Ionian Sea	6969	347361	363895
434	Libya	106	Levantine Sea	48646	421745	363895
434	Libya	138	Tunisian Plateau/Gulf of Sidra	307789	402162	363895
440	Lithuania	97	Baltic Sea	6837	376537	6837
38	Lord Howe Isl. (Australia)	212	Lord Howe and Norfolk Islands	542369	981995	542849
37	Macquarie Isl. (Australia)	167	Macquarie Island	477351	477352	477361
450	Madagascar	34	Cargados Carajos/Tromelin Island	197	930174	1237966
450	Madagascar	89	East African Coral Coast	66	478916	1237966
450	Madagascar	134	Mascarene Islands	957	1058073	1237966
450	Madagascar	182	Seychelles	293	1334015	1237966
450	Madagascar	183	Southeast Madagascar	446036	446163	1237966
450	Madagascar	35	Western and Northern Madagascar	790396	1334065	1237966
621	Madeira Isl. (Portugal)	82	Azores Canaries Madeira	459608	1865442	459608
460	Malaysia (Peninsula East)	230	Malacca Strait	645	168385	132144

460	Malaysia (Peninsula East)	57	Sunda Shelf/Java Sea	131499	1386854	132144
459	Malaysia (Peninsula West)	139	Andaman Sea Coral Coast	1	283433	68386
459	Malaysia (Peninsula West)	230	Malacca Strait	68385	168385	68386
461	Malaysia (Sabah)	123	Palawan/North Borneo	78793	572946	137211
461	Malaysia (Sabah)	146	South China Sea Oceanic Islands	55692	1255398	137211
461	Malaysia (Sabah)	124	Sulawesi Sea/Makassar Strait	2652	740991	137211
463	Malaysia (Sarawak)	123	Palawan/North Borneo	27226	572946	172530
463	Malaysia (Sarawak)	146	South China Sea Oceanic Islands	10099	1255398	172530
463	Malaysia (Sarawak)	57	Sunda Shelf/Java Sea	135242	1386854	172530
462	Maldives	113	Maldives	915486	1318816	924951
470	Malta	104	Ionian Sea	26663	347361	52869
470	Malta	138	Tunisian Plateau/Gulf of Sidra	26210	402162	52869
584	Marshall Isl.	19	Marshall Islands	1992020	2399284	1992021
474	Martinique (France)	116	Eastern Caribbean	47520	868768	47532
478	Mauritania	188	Cape Verde	0	796555	173189
478	Mauritania	81	Saharan Upwelling	17536	558772	173189
478	Mauritania	103	Sahelian Upwelling	155313	335699	173189
480	Mauritius	34	Cargados Carajos/Tromelin Island	800427	930174	2184726
480	Mauritius	114	Chagos	637742	638556	2184726
480	Mauritius	113	Maldives	168	1318816	2184726
480	Mauritius	134	Mascarene Islands	744426	1058073	2184726
480	Mauritius	35	Western and Northern Madagascar	1375	1334065	2184726
175	Mayotte (France)	35	Western and Northern Madagascar	66685	1334065	66685
944	Mexico (Atlantic)	143	Greater Antilles	48	1157222	831791
944	Mexico (Atlantic)	74	Northern Gulf of Mexico	84487	598106	831791
944	Mexico (Atlantic)	122	Southern Gulf of Mexico	653184	688764	831791
944	Mexico (Atlantic)	160	Western Caribbean	94064	242364	831791
945	Mexico (Pacific)	223	Chiapas-Nicaragua	112653	376906	2350734
945	Mexico (Pacific)	171	Cortezian	263522	263522	2350734
945	Mexico (Pacific)	165	Magdalena Transition	187113	227781	2350734
945	Mexico (Pacific)	164	Mexican Tropical Pacific	654372	654372	2350734
945	Mexico (Pacific)	190	Revillagigedos	652065	652265	2350734
945	Mexico (Pacific)	72	Southern California Bight	454895	642335	2350734
583	Micronesia (Federated States of)	67	East Caroline Islands	2462205	2462658	2993056
583	Micronesia (Federated States of)	195	Mariana Islands	0	970769	2993056
583	Micronesia (Federated States of)	19	Marshall Islands	0	2399284	2993056
583	Micronesia (Federated States of)	2	Solomon Archipelago	471	1656641	2993056
583	Micronesia (Federated States of)	186	West Caroline Islands	528542	1134134	2993056
891	Montenegro	221	Adriatic Sea	6352	135271	6352
500	Montserrat (UK)	116	Eastern Caribbean	7210	868768	7210
946	Morocco (Central)	82	Azores Canaries Madeira	5440	1865442	262154
946	Morocco (Central)	81	Saharan Upwelling	256590	558772	262154
946	Morocco (Central)	84	South European Atlantic Shelf	116	800447	262154
947	Morocco (Mediterranean)	80	Alboran Sea	18155	84149	18357
947	Morocco (Mediterranean)	81	Saharan Upwelling	193	558772	18357

947	Morocco (Mediterranean)	84	South European Atlantic Shelf	6	800447	18357
948	Morocco (South)	82	Azores Canaries Madeira	4	1865442	283883
948	Morocco (South)	81	Saharan Upwelling	283858	558772	283883
948	Morocco (South)	103	Sahelian Upwelling	0	335699	283883
508	Mozambique	185	Bight of Sofala/Swamp Coast	199413	199437	565466
508	Mozambique	51	Delagoa	241344	319072	565466
508	Mozambique	89	East African Coral Coast	124129	478916	565466
508	Mozambique	35	Western and Northern Madagascar	612	1334065	565466
251	Mozambique Channel Isl. (France)	185	Bight of Sofala/Swamp Coast	25	199437	310450
251	Mozambique Channel Isl. (France)	51	Delagoa	746	319072	310450
251	Mozambique Channel Isl. (France)	89	East African Coral Coast	31	478916	310450
251	Mozambique Channel Isl. (France)	35	Western and Northern Madagascar	308723	1334065	310450
104	Myanmar	137	Andaman and Nicobar Islands	74522	734098	496873
104	Myanmar	139	Andaman Sea Coral Coast	164756	283433	496873
104	Myanmar	53	Northern Bay of Bengal	256686	485565	496873
516	Namibia	178	Namaqua	207477	477564	560094
516	Namibia	179	Namib	352616	437193	560094
520	Nauru	15	Gilbert/Ellis Islands	308505	2396454	308505
528	Netherlands	41	North Sea	61856	680979	61856
540	New Caledonia (France)	91	Coral Sea	37	968505	1364871
540	New Caledonia (France)	212	Lord Howe and Norfolk Islands	2	981995	1364871
540	New Caledonia (France)	133	New Caledonia	1161563	1252156	1364871
540	New Caledonia (France)	90	Tweed-Moreton	1	279696	1364871
540	New Caledonia (France)	126	Vanuatu	203299	1662460	1364871
554	New Zealand	43	Auckland Island	230538	230538	3478372
554	New Zealand	8	Bounty and Antipodes Islands	518613	519062	3478372
554	New Zealand	44	Campbell Island	309505	309505	3478372
554	New Zealand	158	Central New Zealand	800465	801460	3478372
554	New Zealand	120	Chatham Island	463690	463690	3478372
554	New Zealand	20	Northeastern New Zealand	413798	413798	3478372
554	New Zealand	26	Snares Island	122951	122951	3478372
554	New Zealand	29	South New Zealand	336666	336666	3478372
554	New Zealand	159	Three Kings-North Cape	282117	282117	3478372
949	Nicaragua (Caribbean)	32	Southwestern Caribbean	167053	741578	167053
950	Nicaragua (Pacific)	223	Chiapas-Nicaragua	61424	376906	61424
566	Nigeria	16	Gulf of Guinea Central	177446	382239	211984
566	Nigeria	206	Gulf of Guinea Islands	34538	417522	211984
570	Niue (New Zealand)	129	Tonga Islands	316588	840051	316587
574	Norfolk Isl. (Australia)	212	Lord Howe and Norfolk Islands	430812	981995	430775
574	Norfolk Isl. (Australia)	159	Three Kings-North Cape	0	282117	430775
580	Northern Marianas (USA)	195	Mariana Islands	762892	970769	762893
580	Northern Marianas (USA)	168	Ogasawara Islands	0	1261469	762893
578	Norway	100	North and East Barents Sea	130953	2083243	935066
578	Norway	41	North Sea	99190	680979	935066
578	Norway	140	Northern Norway and Finnmark	319042	352393	935066

578	Norway	98	Southern Norway	385583	385594	935066
512	Oman	151	Gulf of Aden	12098	560060	548073
512	Oman	93	Gulf of Oman	76769	275487	548073
512	Oman	135	Western Arabian Sea	459185	549923	548073
911	Oman (Musandam)	136	Arabian (Persian) Gulf	4782	238347	7018
911	Oman (Musandam)	93	Gulf of Oman	2235	275487	7018
586	Pakistan	93	Gulf of Oman	129573	275487	223772
586	Pakistan	175	Western India	94018	640184	223772
585	Palau	157	Halmahera	96	254860	615115
585	Palau	231	Papua	1273	641475	615115
585	Palau	186	West Caroline Islands	605076	1134134	615115
844	Palmyra Atoll & Kingman Reef (USA)	65	Line Islands	352528	1743769	352528
951	Panama (Caribbean)	32	Southwestern Caribbean	142158	741578	142158
952	Panama (Pacific)	141	Nicoya	79604	288802	188596
952	Panama (Pacific)	180	Panama Bight	108991	525331	188596
598	Papua New Guinea	37	Arafura Sea	27144	370338	2396283
598	Papua New Guinea	109	Arnhem Coast to Gulf of Carpentaria	10	571787	2396283
598	Papua New Guinea	153	Bismarck Sea	757490	757742	2396283
598	Papua New Guinea	91	Coral Sea	624	968505	2396283
598	Papua New Guinea	67	East Caroline Islands	354	2462658	2396283
598	Papua New Guinea	152	Gulf of Papua	68638	68648	2396283
598	Papua New Guinea	231	Papua	656	641475	2396283
598	Papua New Guinea	2	Solomon Archipelago	673210	1656641	2396283
598	Papua New Guinea	3	Solomon Sea	655131	655151	2396283
598	Papua New Guinea	154	Southeast Papua New Guinea	209218	209228	2396283
598	Papua New Guinea	38	Torres Strait Northern Great Barrier Reef	3757	193124	2396283
604	Peru	170	Central Peru	313711	313711	852405
604	Peru	169	Guayaquil	111697	258565	852405
604	Peru	111	Humboldtian	426880	691032	852405
608	Philippines	163	Eastern Philippines	852709	922014	2324649
608	Philippines	123	Palawan/North Borneo	397500	572946	2324649
608	Philippines	146	South China Sea Oceanic Islands	723755	1255398	2324649
608	Philippines	145	South Kuroshio	208886	1461400	2324649
608	Philippines	124	Sulawesi Sea/Makassar Strait	141417	740991	2324649
608	Philippines	186	West Caroline Islands	354	1134134	2324649
612	Pitcairn (UK)	222	Rapa-Pitcairn	836107	1305423	836115
616	Poland	97	Baltic Sea	29797	376537	29797
620	Portugal (mainland)	81	Saharan Upwelling	325	558772	314704
620	Portugal (mainland)	84	South European Atlantic Shelf	314309	800447	314704
711	Prince Edward Isl. (South Africa)	214	Prince Edward Islands	473368	473515	473369
630	Puerto Rico (USA)	161	Bahamian	63387	923316	172818
630	Puerto Rico (USA)	116	Eastern Caribbean	242	868768	172818
630	Puerto Rico (USA)	143	Greater Antilles	109187	1157222	172818
630	Puerto Rico (USA)	127	Southern Caribbean	8	584596	172818
634	Qatar	136	Arabian (Persian) Gulf	30637	238347	30637

638	Réunion (France)	134	Mascarene Islands	312661	1058073	315186
638	Réunion (France)	183	Southeast Madagascar	128	446163	315186
642	Romania	155	Black Sea	30223	460086	30223
648	Russia (Baltic Sea)	97	Baltic Sea	23182	376537	23210
645	Russia (Barents Sea)	100	North and East Barents Sea	1076875	2083243	1197010
645	Russia (Barents Sea)	140	Northern Norway and Finnmark	33377	352393	1197010
645	Russia (Barents Sea)	99	White Sea	87058	87058	1197010
647	Russia (Black Sea)	155	Black Sea	156573	460086	157960
649	Russia (Far East)	177	Aleutian Islands	0	1258111	3396076
649	Russia (Far East)	48	Chukchi Sea	0	646109	3396076
649	Russia (Far East)	17	Eastern Bering Sea	147775	1049507	3396076
649	Russia (Far East)	61	Kamchatka Shelf and Coast	901272	929205	3396076
649	Russia (Far East)	60	Oyashio Current	836960	973047	3396076
649	Russia (Far East)	25	Sea of Japan/East Sea	317516	989381	3396076
649	Russia (Far East)	83	Sea of Okhotsk	1190198	1236094	3396076
912	Russia (Kara Sea)	62	Kara Sea	1058126	1058152	1058125
912	Russia (Kara Sea)	100	North and East Barents Sea	0	2083243	1058125
913	Russia (Laptev to Chukchi Sea)	48	Chukchi Sea	329217	646109	2087448
913	Russia (Laptev to Chukchi Sea)	50	East Siberian Sea	966523	1007529	2087448
913	Russia (Laptev to Chukchi Sea)	62	Kara Sea	0	1058152	2087448
913	Russia (Laptev to Chukchi Sea)	192	Laptev Sea	791574	791610	2087448
908	Saba and Sint Eustatius (Netherlands)	116	Eastern Caribbean	11645	868768	11645
654	Saint Helena (UK)	218	St. Helena and Ascension Islands	444898	886540	444898
659	Saint Kitts & Nevis	116	Eastern Caribbean	9494	868768	9494
662	Saint Lucia	116	Eastern Caribbean	15448	868768	15448
666	Saint Pierre & Miquelon (France)	87	Gulf of St. Lawrence - Eastern Scotian Shelf	3984	439219	12353
666	Saint Pierre & Miquelon (France)	121	Southern Grand Banks - South Newfoundland	8369	337376	12353
670	Saint Vincent & the Grenadines	116	Eastern Caribbean	36195	868768	36204
670	Saint Vincent & the Grenadines	127	Southern Caribbean	9	584596	36204
882	Samoa	78	Phoenix/Tokelau/Northern Cook Islands	20	2539942	131534
882	Samoa	79	Samoa Islands	131490	849376	131534
678	Sao Tome & Principe	16	Gulf of Guinea Central	25	382239	165347
678	Sao Tome & Principe	206	Gulf of Guinea Islands	165322	417522	165347
902	Sardinia (Italy)	144	Western Mediterranean	116735	757567	116735
684	Saudi Arabia (Persian Gulf)	136	Arabian (Persian) Gulf	34039	238347	34039
683	Saudi Arabia (Red Sea)	30	Northern and Central Red Sea	108009	228824	190190
683	Saudi Arabia (Red Sea)	31	Southern Red Sea	82180	225930	190190
686	Senegal	188	Cape Verde	0	796555	186962
686	Senegal	174	Gulf of Guinea West	29053	620646	186962
686	Senegal	103	Sahelian Upwelling	157715	335699	186962
690	Seychelles	34	Cargados Carajos/Tromelin Island	645	930174	1336041
690	Seychelles	182	Seychelles	1331327	1334015	1336041
690	Seychelles	35	Western and Northern Madagascar	4072	1334065	1336041
901	Sicily (Italy)	104	Ionian Sea	46872	347361	105350
901	Sicily (Italy)	138	Tunisian Plateau/Gulf of Sidra	837	402162	105350

901	Sicily (Italy)	144	Western Mediterranean	57672	757567	105350
694	Sierra Leone	174	Gulf of Guinea West	159301	620646	159301
702	Singapore	230	Malacca Strait	745	168385	745
909	Sint Maarten (Netherlands)	116	Eastern Caribbean	469	868768	469
705	Slovenia	221	Adriatic Sea	147	135271	147
90	Solomon Isl.	91	Coral Sea	215	279696	1597930
90	Solomon Isl.	133	New Caledonia	64	1252156	1597930
90	Solomon Isl.	2	Solomon Archipelago	982846	1656641	1597930
90	Solomon Isl.	3	Solomon Sea	6	655151	1597930
90	Solomon Isl.	126	Vanuatu	614899	1662460	1597930
706	Somalia	112	Central Somali Coast	434019	434019	831067
706	Somalia	151	Gulf of Aden	136246	560060	831067
706	Somalia	88	Northern Monsoon Current Coast	260803	260802	831067
953	South Africa (Atlantic and Cape)	196	Agulhas Bank	369595	369595	748154
953	South Africa (Atlantic and Cape)	178	Namaqua	270087	477564	748154
953	South Africa (Atlantic and Cape)	197	Natal	108096	352882	748154
954	South Africa (Indian Ocean Coast)	51	Delagoa	76934	319072	321752
954	South Africa (Indian Ocean Coast)	197	Natal	244787	352882	321752
239	South Georgia & Sandwich Isl. (UK)	215	South Georgia	521636	521723	1277822
239	South Georgia & Sandwich Isl. (UK)	217	South Sandwich Islands	680268	681753	1277822
910	South Orkney Islands (UK)	216	South Orkney Islands	390278	390278	497521
910	South Orkney Islands (UK)	28	South Shetland Islands	15213	341593	497521
962	Spain (mainland, Med and Gulf of Cadiz)	80	Alboran Sea	45198	84149	146291
962	Spain (mainland, Med and Gulf of Cadiz)	81	Saharan Upwelling	2	558772	146291
962	Spain (mainland, Med and Gulf of Cadiz)	84	South European Atlantic Shelf	14657	800447	146291
962	Spain (mainland, Med and Gulf of Cadiz)	144	Western Mediterranean	86432	757567	146291
963	Spain (Northwest)	84	South European Atlantic Shelf	288027	800447	288258
144	Sri Lanka	54	Eastern India	0	420761	530943
144	Sri Lanka	162	South India and Sri Lanka	530943	661444	530943
904	St Barthelemy (France)	116	Eastern Caribbean	4188	868768	4188
905	St Martin (France)	116	Eastern Caribbean	1098	868768	1098
895	St Paul & Amsterdam Isl. (France)	200	Amsterdam-St Paul	509012	509182	509012
970	St Paul and St. Peter Archipelago (Brazil)	24	Sao Pedro and Sao Paulo Islands	413640	413640	413636
736	Sudan	30	Northern and Central Red Sea	48882	228824	82542
736	Sudan	31	Southern Red Sea	33661	225930	82542
740	Suriname	226	Guianan	132278	453298	132451
744	Svalbard Isl. (Norway)	100	North and East Barents Sea	796297	2083243	796297
914	Sweden (Baltic)	97	Baltic Sea	141770	376537	141771
915	Sweden (West Coast)	97	Baltic Sea	867	376537	14548
915	Sweden (West Coast)	41	North Sea	13681	680979	14548
760	Syria	106	Levantine Sea	10288	421745	10288
157	Taiwan	49	East China Sea	129691	686453	1149435
157	Taiwan	176	Gulf of Tonkin	1	289433	1149435
157	Taiwan	123	Palawan/North Borneo	12	572946	1149435
157	Taiwan	146	South China Sea Oceanic Islands	872731	1255398	1149435

157	Taiwan	145	South Kuroshio	67917	1461400	1149435
157	Taiwan	184	Southern China	79041	283612	1149435
834	Tanzania	89	East African Coral Coast	240936	478916	241124
834	Tanzania	182	Seychelles	0	1334015	241124
834	Tanzania	35	Western and Northern Madagascar	188	1334065	241124
956	Thailand (Andaman Sea)	139	Andaman Sea Coral Coast	118676	283433	118728
956	Thailand (Andaman Sea)	230	Malacca Strait	51	168385	118728
957	Thailand (Gulf of Thailand)	56	Gulf of Thailand	178651	266482	179155
957	Thailand (Gulf of Thailand)	57	Sunda Shelf/Java Sea	471	1386854	179155
626	Timor Leste	5	Banda Sea	3005	941189	78230
626	Timor Leste	108	Bonaparte Coast	95	291172	78230
626	Timor Leste	128	Lesser Sunda	75130	717561	78230
768	Togo	16	Gulf of Guinea Central	15450	382239	15450
772	Tokelau (New Zealand)	78	Phoenix/Tokelau/Northern Cook Islands	319054	2539942	319053
772	Tokelau (New Zealand)	79	Samoa Islands	0	849376	319053
776	Tonga	68	Fiji Islands	2	786024	664786
776	Tonga	79	Samoa Islands	141323	849376	664786
776	Tonga	129	Tonga Islands	523464	840051	664786
77	Trindade & Martim Vaz Isl. (Brazil)	52	Eastern Brazil	0	674995	468599
77	Trindade & Martim Vaz Isl. (Brazil)	42	Trindade and Martin Vaz Islands	468599	468608	468599
780	Trinidad & Tobago	116	Eastern Caribbean	1203	868768	80218
780	Trinidad & Tobago	226	Guianan	23695	453298	80218
780	Trinidad & Tobago	127	Southern Caribbean	55311	584596	80218
856	Tristan da Cunha Isl. (UK)	219	Tristan Gough	755105	1053047	813830
252	Tromelin Isl. (France)	34	Cargados Carajos/Tromelin Island	270678	930174	273520
252	Tromelin Isl. (France)	134	Mascarene Islands	1468	1058073	273520
252	Tromelin Isl. (France)	35	Western and Northern Madagascar	1375	1334065	273520
788	Tunisia	104	Ionian Sea	65	347361	99906
788	Tunisia	138	Tunisian Plateau/Gulf of Sidra	67274	402162	99906
788	Tunisia	144	Western Mediterranean	32575	757567	99906
794	Turkey (Black Sea)	155	Black Sea	172478	460086	172478
966	Turkey (Marmara Sea)	105	Aegean Sea	11653	375812	11653
793	Turkey (Mediterranean Sea)	105	Aegean Sea	29397	375812	78102
793	Turkey (Mediterranean Sea)	106	Levantine Sea	48693	421745	78102
796	Turks & Caicos Isl. (UK)	161	Bahamian	90586	923316	90838
798	Tuvalu	15	Gilbert/Ellis Islands	751419	2396454	751747
798	Tuvalu	79	Samoa Islands	1	849376	751747
804	Ukraine	155	Black Sea	133416	460086	133418
784	United Arab Emirates	136	Arabian (Persian) Gulf	54445	238347	54445
968	United Arab Emirates (Fujairah)	136	Arabian (Persian) Gulf	0	238347	4424
968	United Arab Emirates (Fujairah)	93	Gulf of Oman	4424	275487	4424
826	United Kingdom (UK)	85	Celtic Seas	383999	879067	732663
826	United Kingdom (UK)	39	Faroe Plateau	1405	267926	732663
826	United Kingdom (UK)	41	North Sea	346989	680979	732663
858	Uruguay	130	Rio de la Plata	16235	31666	162929

858	Uruguay	132	Rio Grande	36	283176	162929
858	Uruguay	131	Uruguay-Buenos Aires Shelf	146446	400686	162929
850	US Virgin Isl.	161	Bahamian	472	923316	38259
850	US Virgin Isl.	116	Eastern Caribbean	33502	868768	38259
850	US Virgin Isl.	143	Greater Antilles	4285	1157222	38259
958	USA (Alaska, Arctic)	47	Beaufort Sea - continental coast and shelf	227695	503059	508181
958	USA (Alaska, Arctic)	48	Chukchi Sea	280486	646109	508181
959	USA (Alaska, Subarctic)	177	Aleutian Islands	1258109	1258111	3198131
959	USA (Alaska, Subarctic)	48	Chukchi Sea	0	646109	3198131
959	USA (Alaska, Subarctic)	17	Eastern Bering Sea	901747	1049507	3198131
959	USA (Alaska, Subarctic)	172	Gulf of Alaska	870831	870831	3198131
959	USA (Alaska, Subarctic)	61	Kamchatka Shelf and Coast	9636	929205	3198131
959	USA (Alaska, Subarctic)	166	North American Pacific Fijordland	155656	478070	3198131
851	USA (East Coast)	161	Bahamian	33598	923316	925167
851	USA (East Coast)	173	Carolinian	370086	370086	925167
851	USA (East Coast)	75	Floridian	45993	229441	925167
851	USA (East Coast)	143	Greater Antilles	125	1157222	925167
851	USA (East Coast)	55	Gulf of Maine/Bay of Fundy	138207	198833	925167
851	USA (East Coast)	92	Virginian	337157	337157	925167
852	USA (Gulf of Mexico)	75	Floridian	181919	229441	695619
852	USA (Gulf of Mexico)	143	Greater Antilles	33	1157222	695619
852	USA (Gulf of Mexico)	74	Northern Gulf of Mexico	513615	598106	695619
852	USA (Gulf of Mexico)	122	Southern Gulf of Mexico	53	688764	695619
848	USA (West Coast)	71	Northern California	402773	402773	822713
848	USA (West Coast)	142	Oregon, Washington, Vancouver Coast and Shelf	312818	437987	822713
848	USA (West Coast)	181	Puget Trough/Georgia Basin	6457	15770	822713
848	USA (West Coast)	72	Southern California Bight	100662	642335	822713
548	Vanuatu	133	New Caledonia	11	1252156	811151
548	Vanuatu	126	Vanuatu	811178	1662460	811151
862	Venezuela	116	Eastern Caribbean	91220	868768	472938
862	Venezuela	143	Greater Antilles	736	1157222	472938
862	Venezuela	226	Guianan	32026	453298	472938
862	Venezuela	127	Southern Caribbean	348969	584596	472938
704	Viet Nam	56	Gulf of Thailand	39234	266482	1441983
704	Viet Nam	176	Gulf of Tonkin	145622	289433	1441983
704	Viet Nam	123	Palawan/North Borneo	12	572946	1441983
704	Viet Nam	146	South China Sea Oceanic Islands	865308	1255398	1441983
704	Viet Nam	184	Southern China	0	283612	1441983
704	Viet Nam	150	Southern Vietnam	181956	181956	1441983
704	Viet Nam	57	Sunda Shelf/Java Sea	209850	1386854	1441983
872	Wake Isl. (USA)	19	Marshall Islands	407241	2399284	407241
876	Wallis & Futuna Isl. (France)	68	Fiji Islands	2	786024	261313
876	Wallis & Futuna Isl. (France)	15	Gilbert/Ellis Islands	3039	2396454	261313
876	Wallis & Futuna Isl. (France)	79	Samoa Islands	258277	849376	261313
917	Yemen (Arabian Sea)	151	Gulf of Aden	400555	560060	491292

917	Yemen (Arabian Sea)	135	Western Arabian Sea	90732	549923	491292
916	Yemen (Red Sea)	151	Gulf of Aden	1608	560060	35677
916	Yemen (Red Sea)	31	Southern Red Sea	34070	225930	35677

Appendix E: *Sea Around Us* Experts Network

The table below provides the names and institutions of fisheries experts who helped us review the assessment for countries where catch and assessment data were: 1) numerous and thus it was important that we use the correct and most recent prior; or 2) scarce and thus the input of an expert might improve the assessments. Invitations were sent to more potential reviewers in more countries than are listed here, but the table lists only colleagues who responded positively, and to whom we here express our sincerest thanks.

Country	***Sea Around Us* contacts**	# Contacted	# Engaged
Australia	Beth Fulton (CSIRO, Canberra, Australia); Graham Edgar (University of Tasmania; Brent Wise (Department of Primary Industries & Regional Development))	3	3
Bahamas	Nicola Smith (Simon Fraser University, Vancouver, Canada)	1	1
Bangladesh	Hadayet Ullah (WorldFish, Dhaka, Bangladesh)	1	1
Canada	Jeff Hutchings (Dalhousie University, Halifax, Canada)	3	1
Cape Verde	Nuno Vieira and Alciany da Luz (INDP, Mindelo, Cape Verde)	2	2
Cyprus, Republic of	Giuseppe Scarcella (CNR, Verona, Italy)	1	1
France (Atlantic)	Rainer Froese (GEOMAR, Kiel, Germany)	1	1
France (Med)	Myriam Khalfallah (IOF, Vancouver, Canada); Giuseppe Scarcella; Athanassios Tsikliras (Aristotle University of Thessaloniki, Thessaloniki, Greece)	4	3
Gabon	Myriam Khalfallah	1	1
Germany	Rainer Froese	1	1
Greece	Athanassios Tsikliras	1	1
Indonesia	Austin Humphries (University of Rhode Island, Rhode Island, USA)	1	1
Iran	Myriam Khalfallah	1	1
Ireland	Rainer Froese	1	1
Italy	Giuseppe Scarcella	1	1
Jordan	Myriam Khalfallah	1	1
Kenya	Paul Tuda (WIOMSA, Mombasa, Kenya)	1	1
Kuwait	Myriam Khalfallah	1	1
Malaysia	Mazlin Mokhtar (Universiti Kebangsaan, Selangor, Malaysia)	1	1
Malta	Athanassios Tsikliras	1	1
Mexico	Andres and Miguel Cisneros-Montemayor (IOF, Vancouver, Canada); Mauricio Ramirez, Francisco Arreguin (CICIMAR, La Paz, Mexico); Enrique Morales (CIBNOR; La Paz, Mexico); Hector Reyes (Universidad Autónoma de Baja California Sur, La Paz, Mexico); Alvaro Hernandez, Silvia Salas (Universidad Marista de Mérida, Mérida, Mexico); Fernando Marquez (Universidad Autónoma de Sinaloa, Sinaloa, Mexico)	10	4
Morocco	Myriam Khalfallah	1	1
Mozambique	Paul Tuda	1	1
Namibia	John Kathena (MFMR, Rundu, Namibia)	2	1
New Zealand	Barry Torkington (New Zealand Asia Institute, Auckland, New Zealand)	1	1
Oman	Myriam Khalfallah	1	1

Pakistan	Hadayet Ullah (WorldFish, Dhaka, Bangladesh)	1	1
Peru	Santiago de la Puente (IOF, Vancouver, Canada)	1	1
Philippines	Maria Lourdes D. Palomares (IOF, Vancouver, Canada)	1	1
Saudi Arabia	Myriam Khalfallah	1	1
Senegal	Beyah Meisse (IMROP, La Batterie, Mauritania)	2	1
Somalia	Abdiwahid (Joar) Hersi (IGAD, Djibouti, Somalia)	3	1
Spain (Atlantic)	Rainer Froese	1	1
Spain (Med)	Myriam Khalfallah, Giuseppe Scarcella, Athanassios Tsikliras	4	3
Sweden	Rainer Froese	1	1
Tanzania, United Republic of	Paul Tuda	1	1
Tunisia	Myriam Khalfallah	1	1
Turkey	Nazli Demirel (Istanbul University, Istanbul, Turkey)	1	1
Total		**62**	**48**

The Commonwealth Scientific and Industrial Research Organisation (CSIRO); National Institute of Fisheries Development (INDP); National Research Council (CNR); Research Center for Marine Geosciences (GEOMAR); Institute for the Oceans and Fisheries (IOF); The Western Indian Ocean Marine Science Association (WIOMSA); The Interdisciplinary Center for Marine Sciences (CICIMAR); Northeast Biological Research Center (CIBNOR); Ministry of Fisheries and Marine Resources (MFMR); Mauritanian Institute for Oceanographic Research and Fisheries (IMROP); Intergovernmental Authority on Development (IGAD).