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Marine Conservation and Fisheries: The Challenges Ahead

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Índice

Abreviaturas

CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals
EEZ	Exclusive Economic Zone
FAO	United Nations Food and Agriculture Organization
GDP	Gross Domestic Product
GFW	Global Fishing Watch
IATTC	Inter-American Tropical Tuna Commission
MPA	Marine Protected Area
PRODUCE	Ministry of Production of Peru
SDGs	Sustainable Development Goals
SERNAPESCA	National Fisheries and Aquaculture Service
SPRFMO	South Pacific Regional Fisheries Management Organization
SUBPESCA	Sub-Secretariat for Fisheries and Aquaculture
UNCLOS	United Nations Convention on the Law of the Sea

Introduction

The oceans are socio-ecological systems of enormous complexity and great importance for humanity. The diversity of ecosystem services they offer makes them essential for our wellbeing. Oceans occupy 71% of the earth's surface and are home to millions of marine species that provide food, enable employment and income opportunities, support cultural values and provide genetic resources for R&D.

Fishing is our main relationship with the sea and therefore multiple fishing techniques and methods have been improved over the years, achieving a very high efficiency. The current capacity of fishing allows the use of open sea resources, hundreds of kilometers deep, facilitating millions of tons of captures. Fishing pressure, together with coastal development processes, marine pollution, habitat degradation and climate change, generate uncertainty in terms of the supply capacity of marine ecosystems services for the near future.

The objective of this Policy Brief is to provide an introductory look into the complex reality of oceans and fisheries, with particular focus on Latin America. Issues addressed will include: ecological and social aspects (e.g. contribution to food security, employment and income) and governance (e.g. international processes for the management and administration of resources, as well as open access tools for adequate decision-making). Finally, we close with conclusions and recommendations to contribute to responsible, effective and sustainable management of marine resources and ecosystems.

The critical role of the oceans

Oceans are of utmost importance for the survival and welfare of mankind. These ecosystems cover 71% of the planet's surface and play key roles in terms of climate and ecological regulation. This includes for example, regulating the water cycle as well as the global atmospheric temperature. The seas are also nutrient reservoirs and capture around 30% of our CO2 emissions. Therefore, it is essential to maintain healthy oceans in order to achieve an atmosphere for human development (Costanza, 1999).

Ecosystem services provided by the oceans include food (i.e. fish, invertebrates, algae), employment, mineral resources, means of transport and cultural values. For example, coastal areas, mangroves, wetlands, sea grasses, coral reefs, and the continental platform cover only 6.3% of the planet's surface, and it is estimated that the monetary contribution to global economy ranges between 3 and 6 trillion dollars a year (UN, 2017).

The diversity of ecosystem services offered by the oceans is partly due to their great diversity and ecological complexity. In terms of biodiversity, it is estimated that marine species outnumber the terrestrial species. While on land, species are restricted to a limited vertical distribution; species in the oceans extend from the surface to 13 km. in depth, with a horizontal extension of thousands of kilometers. To date, it is estimated that 0.7 to 1 million marine species exist, of which 90% are still unknown (UN, 2017).

However, due to the huge extension of the oceans, these have been considered as endless sources of natural resources or perfect destinations for our garbage. To this erroneous perception one can add the complexity of governing and managing ecosystems whose fuzzy borders do not correspond to political boundaries. Additionally, mankind has been largely unsuccessful in detaining the uncontrolled growth of the extractive and transformative capacity we hold over oceans. Therefore, many living marine resources are critically endangered, victims of unsustainable and highly resilient conducts.

In terms of climate change, its effects on marine ecosystems are only now being understood. Several studies indicate that temperature increase shall reduce the availability of oxygen in the seas, altering in turn other biogeochemical properties and affecting the distribution, productivity and also the size of marine organisms (Cheung *et al*., 2009; 2013). These changes will mainly affect tropical and subtropical regions, where the reduction in the diversity and abundance of marine species will directly impact the well-being of coastal communities.

Given that 10% of the world's population lives in coastal zones, the pressure on these ecosystems is severe and continuous, and leads to its progressive degradation. In this context, the concept of Blue Economy has been gaining significance in international processes which seek comprehensive and sustainable management of oceans. The Blue Economy seeks to put into perspective the multiplicity of services oceans provide in order to develop comprehensive, sustainable and socially equitable guidelines that allow benefits for present and future generations, ensuring the functionality of marine ecosystems (UNEP, 2015). Among economic activities highlighted for the implementation of a Blue Economy is tourism, renewable energy, fisheries and integral waste management (World Bank, 2018). For further reference on opportunities for Peru under the framework of a Blue Economy, see the study by McKinley *et al*., (2018) and for an international perspective see Silver *et al*. (2015).

The critical role of fisheries and mariculture

Among these economic activities, fishing stands out due to its contribution to food, employment and associated cultural and social values. Our relationship with the seas begins through food, collecting fish and mollusks near the shores starting 15,000 years ago (Jacquet, 2009). As years go by, the first coastal populations begin to develop fishing gear and techniques to increase food demands. Peru is a clear example of this evolution, having implemented advanced fishing techniques, navigating on Caballitos de Totora (reed watercrafts) as early as 1550 A.C. (Prieto, 2013). In South East Asia, evidence of pelagic species fisheries can be traced back 42,000 years in the Islands of Timor (Prieto, 2013).

Due to the social and ecological dimensions of fishing, this activity includes two connected sub-systems, the human and biophysical, interacting through ecological, economic, social and cultural components (Charles, 2014).

Fishing is divided into industrial and artisanal fishing, both of significant importance for food and employment. Artisanal fishing has been taking place since time immemorial, while industrial fishing experienced a technological revolution after World War II (Pauly *et al*., 2002). By 2016, global fisheries reached 80 million tons of landings, mainly intended for direct human consumption (FAO, 2018). Additionally, it is estimated that fishing contributes with US$100 billion a year and generates directly and indirectly around 56 million jobs, employing 12% of the world's population (FAO, 2018).

In terms of nourishment, fisheries resources provide 17% of animal protein consumed by the world's population (FAO, 2018). This is of utmost importance for developing countries as it represents food with a high nutritional value. In addition, the consumption of proteins from marine sources has increased at the global level: consumption *per* capita has gone from 9 kg. in 1961 to 20.2 kg. in 2015 (FAO, 2018). Furthermore, fish and shellfish have become the most commercialized food products in the world (Kittinger *et al*., 2017).

In order to contextualize the importance of fishing, in Peru there are about 70,000 artisanal fishers and 10,000 industrial fishers (Castillo-Mendoza *et al*., 2018). Almost 80% of fishing products for direct human consumption come from artisanal fishing, benefitting from around 200 different species. Industrial fisheries capture close to 5 million tons a year, almost exclusively anchovy (*Engraulis ringens*), intended for the production of fishmeal and fish oil. Nevertheless, due to the economic multipliers from these extractive activities, the fisheries sector in Peru generates more than 230,000 jobs and a yearly contribution of USD 2.1 billion to the Gross Domestic Product (Christensen *et al*., 2014a).

In Chile, the fisheries sector represents 0.4% of GDP, and 90% corresponds to aquaculture sales to people for direct consumption (Palacios-Abrantres *et al*., 2018). In terms of employment, fisheries contribute with nearly 278,000 jobs – 33% associated to fishing, 6% to aquaculture and 61% to transformation, processing and distribution of products (Palacios-Abrantres *et al*., 2018).

In the case of Brazil, it is estimated that 500,000 fishers operate in the country; 90% are part of the artisanal sector and 10% are employed in industrial fishing activities. The latter is responsible for between 30%-50% of total captures (Campos and Chavez, 2016).

The state of the sea and its resources

As mentioned previously, fisheries activities extended globally during the decades following the Second World War, expanding in terms of geography (from the northern to the southern hemisphere), bathymetry (from the surface to deep sea areas), and taxonomy (gradually involving a greater number of target species) (Pauly, 2009). However, due to the deterioration of stocks and growth of aquaculture activity, their contribution to the total fishery production is progressively decreasing since 1996 (Pauly & Zeller, 2016).

The increase in the capacity and efficiency of fisheries has been excessive. This has led to higher levels of capture with a direct affect on the regenerative capacity of exploited species, producing the collapse of numerous fisheries and negatively impacting marine ecosystems and social systems that depend on them (Myers & Worm, 20013; Daly, 2005; Worm *et al*., 2006; Halpern *et al*., 2008). This extractive capacity has meant the overexploitation of the majority of fish stocks. According to the last report by FAO, the condition of marine stocks continues to decrease (FAO, 2018). By 2015, 33% of stocks exploited commercially were overexploited, 60% through fishing at their maximum sustainable limit. Only 7% of stocks are sub-exploited (FAO, 2018).

Nevertheless, the critical situation of fisheries resources is not sufficiently evidenced in conservation and management policies at the national and international level. This can be partly attributed to the shifting baseline syndrome. It refers to the loss of collective memory in terms of the state of natural resources and ecosystems, accepting what we currently see and experience as the 'new normal state', dismissing that the seas were in a better situation in the past (Pauly, 1995). If a fisher of the 1950s would see the state of fisheries at the present time, he would immediately notice the loss of top predators or a reduction in the size of resources; while a fisher just initiating his work this year would consider what he sees as the natural or 'normal' condition of the system.

Nowadays, there are clear symptoms that marine ecosystems are deteriorating. For example, during the past 100 years we have observed a progressive decrease in the abundance of marine predators at the global level, including sharks, tuna and marine birds (Christensen *et al*., 2014b).

Finally, over the years, biomass of the most important fish stocks in the world has been decreasing (Pauly *et al.,* 2002). In areas where fisheries management has been successfully implemented, an important recovery of overexploited stocks has been observed, as well as the maintenance of exploited resources in healthy population conditions (Melnychuk *et al*., 2017; Pons *et al.*, 2018). Nevertheless, as fishers capture prey and predators in the same ecosystems, it is impossible to manage all resources at the maximum level of sustainable yield (Walters *et al*., 2005). This is especially relevant given recent evidence that marine species are being lost at double the rate of land species (Pinsky et al., 2019) and there is no equal evidence of recuperation of stocks globally of endangered species and the services they provide (IPBES, 2019).

For these reasons it is of utmost importance that fisheries management adopts an ecosystem approach (Walters & Martel, 2004), mainly in the context of climate change, where climate patterns involve greater uncertainty, making our capacity to predict the impact of management measures difficult (Walters & Martel, 2004).

International Agreements and Treaties

There are currently several national and international processes that promote the conservation and sustainable management of living marine resources and the ecosystems they inhabit. One of the most important multilateral treaties is the United Nations Convention on the Law of the Sea (UNCLOS), approved in 1982. Beyond recognizing the exclusive economic zones of member countries, UNCLOS establishes the obligation of States to ensure the conservation and sustainable management of marine natural resources in both in jurisdictional and international waters.

In terms of marine biodiversity conservation, the Aichi Biodiversity Targets are a set of goals approved in the context of the Convention on Biological Diversity (CGD). Target number 11 indicates that by 2020, at least 10% of coastal and marine areas of particular importance for biodiversity and ecosystem services are conserved through effective measures. This has led to a significant increase in the number of marine protected areas (MPAs) at the world level since 2000. At present, there are 14,830 MPAs, protecting 7.6% of the oceans (UNEP-WCMC & IUCN, 2019). At this moment Peru has only protected 0.48% of its sea through four coastal-marine protected areas, and the first complete MPA is in the process of being approved since 2016 (SPDA, 2018). Other countries such as Mexico have greater levels of protection. For example, Mexico has protected 22.3% of its marine domain, whilst Chile has protected 42% (Solano and Galvez, 2019). Other key convention for marine biodiversity protection are CITES, CMS and RAMSAR (see Table 1).

Table 1:

Objectives and key legal content of the most relevant international conventions for marine biodiversity protection

Conventions	Objective	Legal character
Convention on International Trade in Endangered Species of Wild Fauna and Flora	Control the international trade of species vulnerable to extinction, or unregulated trade that may be a threat to their sustainable use.	Procedures vary according the list of species in Appendix I, II and III. Around 5,800 animal species and 30,000 plant species are registered in CITES.
Convention on the Conservation of Migratory Species of Wild Animals	Provides a global platform for the conservation and sustainable use of migratory species and their habitats.	Endangered migratory species featured in Appendix I, and those benefitting from international cooperation in Appendix II. Appendix I has a total of 57 registered species, 1,013 in Appendix II and 116 in both Appendixes.
RAMSAR Convention	Conservation and rational use of wetlands through local and national actions, and thanks to international cooperation.	There are 2,200 RAMSAR sites, covering a surface of 250 million hectares.

In terms of fisheries management, FAO adopted a Code of Conduct for Responsible Fisheries in 1995. This code is voluntary but is an important reference for the development of policies and legal frameworks in support of fisheries sustainability and social welfare. It establishes international principles and standards of conduct for responsible fisheries practices, in order to ensure the activities conservation, management and development, respecting the natural limits of marine ecosystems and their biodiversity. Many countries have adopted this code in their internal fishing regulations. However, performance in implementation, sustainability and conservation has been varied (Pitcher and Preikshot, 2001; FAO 2012).

Another international instrument for fisheries management are Regional Fisheries Organizations (RFOs). These are organizations concentrated on countries with common interests on fisheries resources in determined zones or highly migratory species. The majority of RFOs establish catch limits and impose technical measures and control obligations. An example is the Inter American Tropical Tuna Commission (IATTC), with 21 member countries, responsible for the conservation and management of tuna in the Eastern Pacific Ocean.

Finally, under the Sustainable Development Goals (SDGs), Goal 14 "life below water" sets a series of principles with regards to the conservation and sustainable use of oceans, seas and marine resources for sustainable development. Goal 14 includes ecological and social targets, including related to marine pollution, the need to restore marine habitats, reduce acidification impacts, eliminate overfishing and illegal fishing, the conservation of marine areas, eliminate perverse subsidies for fishing, and how to increase economic benefits associated to developing countries. A recent study found that reaching the targets of Goal 14 would increase the potential of society to contribute in achieving other goals for sustainable development (Singh *et al*., 2018).

Global digital data repositories

A basic aspect to advance towards sustainable use of healthy marine ecosystems is the exchange of information. Therefore, diverse groups are working to create, maintain and manage free access digital repositories of global data. These are multilateral efforts that provide useful information for the management and conservation of living marine resources and marine biodiversity. Information has been published in peer-reviewed specialized scientific magazines and can be freely downloaded to seek the response of specific research questions.

Below we offer a list of the main repositories:

- **FishBase**: The most comprehensive register of marine species (at present comprised of 34,200 species) that provides biological and ecological type information and the vulnerability state of species. Available at: <www.seaaroundus.org>.

- **Sea Around Us**: A research initiative that evaluates the impact of fisheries on marine ecosystems around the world. Since 1950 it has been reporting catch data by species, country and region, as well as reconstructed catch data and data associated to fisheries activities. Available at: <www.seaaroundus.org>.

- **FAOSTAT**: A free access FAO database on food and agriculture of 245 countries and territories, with data since 1961. Available at:

- **FAO Fish Stat J**: A free Access FAO database on global fisheries and aquaculture production, with data since 1950. Available at:

- **RAM Legacy Stock Assessment Database**: A compilation of stock assessment results for commercially exploited marine populations from around the world. Available at:

New trends in terms of fisheries management

Fisheries management is a comprehensive process that involves the collection and analysis of information, as well as planning, consulting and decision making with regards to fisheries management (Cochrane, 2005). This process includes regulating fisheries, including the assignment of rights, and taxable and punitive aspects in order to ensure the productivity of resources and achieve the agreed management objectives. Following are some management measures that have been gaining importance in recent decades.

Individual Quota Systems

Globally, the most common mechanism to regulate output limits (namely management measures that seek to prevent excessive fish catches) is the general catch quota (Caddy, 1999). This means that state or regulatory bodies must establish a cap to the extraction of a particular resource, in a determined area and period of time. Nevertheless, general quotas lead the administrators to seek an increase in their fishing power and therefore displace their competitors. They invest in the expansion of their fleets, with larger and better-equipped vessels. As a consequence, fleets are increasing excessively (fishing overcapacity), progressively capturing catch quotas in a shorter period of time (race for fishing). This process gives rise to cost overruns that end up motivating the administrators to undertake catches over the established limits, and consequently to overfishing (Aderson & Seijo, 2010).

In order to address this and following global trends, *individual* catch quotas are being implemented. These are schemes whereby a vessel, a ship owner or groups of owners obtain exclusive access during a period of time, at a fraction of the general catch quota (Caddy, 1999). In theory, granting the users exclusive access motivates them to protect the resources they exploit as overfishing directly contravenes their interests. This situation would not occur in alternative schemes, where the administrators lack guarantees regarding future benefits from management actions that restrict catches at the present time (Anderson & Seijo, 2010).This is one of the main regulations for fisheries in Australia, Canada, United States and Europe, and is gaining importance in Latin American countries such as Argentine, Chile, Mexico and Peru (EDF, 2018).

Co-Management Fisheries Resources

In the context of Latin America, one of the main reasons for ineffective fisheries management and poor compliance with the law is that regulations have followed a vertical process by the central government (top-down). As a countermeasure, co-management is proposed, seeking to solve management failures by the government and ensure the adaptive capacity of fishers in the face of unexpected changes and environmental uncertainty (Adger & Adger, 2003). Co-management is defined as a participative and collaborative process among the diverse groups of decision-makers with regard to regulatory processes (Jentoft, 1989). Co-management increases the sense of responsibility among fishers and provides greater legitimacy to resources control mechanisms (Kosamu, 2015). In addition, by incorporating the empirical knowledge of fishers, management schemes respond rapidly and appropriately to changes in the system.

Successful co-management cases in Latin America are few for the moment. An example of a successful case is an artisanal fishery initiative of Chile. In Chile, loco fishing (*Cocholepas concholepas*) collapsed at the end of the1980s due to unsustainable levels of exploitation (Castilla & Gelcich, 2008). This collapse encouraged the introduction of Benthic Resources Management Areas that grant fishers exclusive rights over different species of benthic resources. By granting exclusive rights, direct incentives are generated for their sustainable use among major users (Crona *et al*., 2017). It has been noted that areas under this type of management tend to have a greater diversity of species, biomass and density (Gelcich *et al*., 2012).

On the other hand, Peru has important initiatives that seek co-management at the level of artisanal fishing. Mariculture of the Peruvian scallop (*Argopecten purpuratus*) in the Bahía de Sechura is an example. In 2016 a management committee was created with fishers representatives, diverse authorities and non-governmental organizations, to determine regulatory decisions in a collaborative manner. Nevertheless, collaboration and confidence among actors need to be improved, in order to provide greater capacity of resilience and adaptation to the system, which is highly vulnerable to changes in the oceanographic conditions and international markets (López de la Lama *et al*., 2018).

Marine Spatial Planning

During the last two decades, the exercise of marine spatial planning has become important for the sustainable management of marine resources and ecosystems, mainly in the context of the Blue Economy. The objective of this exercise is to contribute to a more sustainable and balanced use of the resources, by incorporating the special element to decide what outputs are produced in a particular marine area over time (Gee et al., 2017). It is under this framework that conservation objectives in marine protected areas and management objectives of fisheries activities can be jointly developed. More recently, considerations of highly biodiverse and ecologically sensitive areas are being incorporated, as well as significant cultural and social elements.

This is a key element to avoid and manage the conflicts among multiple actors that share the same space. It is necessary, as fishing does not occur in a context isolated from other economic activities (i.e. tourism, sea transport, and hydrocarbon exploitation) and/or social interests (i.e. biodiversity conservation, food security and job creation). In this context, Chile has made significant progress, mapping vulnerable marine ecosystems established in the Fisheries and Aquaculture Law. This allows a ban on fisheries extractive activities with fishing tackle and fishing gear that affects the seabed, such as trawl fishing on the seamounts.

Promoting traceability and transparency

Traceability and transparency systems are key in ensuring sustainable use of marine ecosystems and their biodiversity. With traceability systems one is able to track living marine resources through their value chains from the catch to the consumer, identifying fully all actors that interact with them, as well as the transformation processes they are subject to. On the other hand, transparency involves effective communication of processes within the fisheries chains (i.e. technical basis behind fishery regulations) and the free availability of

information (i.e. from the statistics on regional catches to records on inputs purchased by companies processing fishery products), in order to ensure that other agents are capable of replicating the methods described, achieving equal results and conclusions as described in management decisions.

An important initiative in this context is Global Fishing Watch (GFW). Peru is the first country in the region -and second in the world, after Indonesia- that allows all data collected by the Satellite Tracking System to be available on the GFW data portal. This initiative discloses information on an open access online platform of the tracking and fishing areas of both national and foreign flag vessels. This enables citizens, governments, companies and non-governmental organizations to monitor vessel performance in real time, strengthening national inspection systems to combat illegal fishing. Few fisheries have this certification in Latin America. Chile has 5 fisheries certified with MSC, Mexico has 4 and Surinam and Bahamas have one each.

On the other hand, there are certification initiatives such as the Marine Stewardship Council (MSC) and the Aquaculture Stewardship Council (ASC) that seek to provide additional economic value to fisheries and aquaculture producers that comply with parameters that allow the sustainable management of marine stocks and habitats, whose products are traceable towards a determined stock. By 2019, Chile has 4 fisheries (artisanal and industrial) certified by the MSC, while Mexico has 3 and Peru none.

Challenges to ensure the sustainable development of oceans and fisheries

Both artisanal and industrial fishing pose three great challenges to ensure their perpetual development and growth through the recovery of overexploited stocks. These challenges are: (1) guaranteeing the sustainable management of the target resources; (2) minimizing the negative ecosystem impacts from fisheries activities and (3) strengthening fisheries governance.

Towards sustainable management of target resources

Guaranteeing sustainable management of fishery target resources requires regulatory bodies, states or regional organizations of fisheries management to ensure that the rates of resource exploitation do not exceed their regenerative capacity, adopting an adverse attitude to risk in the face of uncertainty (Walters & Martell, 2004). This is essential, as the effectiveness of management measures, such as individual catch quotas, is conditional to the general quota being correctly defined (Anderson & Seijo, 2010).

Fisheries that develop in marine ecosystems with highly variable oceanographic conditions require adaptive fisheries management tools. Therefore, catch quotas must be set consistent with extraction rates that vary according to the state of the ecosystems and biomass of the target resource, using biological reference points (Walters & Martell, 2004). Catch quotas must not be set based on fixed values such as the maximum sustainable yield, whose consistency has greater validity in stable ecosystems, but with limitations known and discussed since the 1970s decade (Larkin, 1977). Extraction rates (adaptive) must be accompanied by measures that limit access and fishing efforts, as well as those that prevent the capture of juvenile individuals (minimum sizes) and protect spawning and breeding areas (fisheries exclusion zones and natural protected areas) (Anderson & Seijo, 2010).

A successful example to this effect is fisheries management of Peru's north-center anchovy quota. It is highly adaptive, using biological reference points to define quotas, applying precautionary principles in the face of potential changes in the state of the marine environment and relying on measures that limit the access to fishing (Oliveros-Ramos & Díaz Acuña, 2015). Additionally, this fishery has an efficient monitoring system, as well as continuous assessments on state of the resource.

Furthermore, fishery policies must have explicit and quantifiable management objectives, so their performance is monitored, modeled and evaluated, recognizing mutual concessions among agreed targets and their impact on actors involved in fisheries (Walters & Martell, 2004). In addition, countries must avoid practices that overshadow the real state of industrial fisheries. For example, Chile continuously publishes evaluations on the state of its fisheries on the official web portals of fisheries authorities.

On the other hand, perverse fisheries subsidies should be eliminated as it produces economic losses at the present time (i.e. public funds destined to subsidize fisheries)

and in the future, and prevents the recovery of overexploited stocks (Pauly, 2009; Anderson & Seijo, 2010). For example, industrial fisheries in Mexico are heavily subsidized, allocating around USD 73 million a year to reduce the cost of vessel fuel (Cisneros-Montemayor *et al*., 2016). This has promoted overfishing of resources such as sardines and prawns, where the economic profitability of industrial fishing would be negative without subsidies (Cisneros-Montemayor *et al*., 2013).

Towards fisheries management with an ecosystem approach

Fisheries cannot be separated from the ecosystems in which they develop. The resources extracted play various ecological roles by interacting with other species. Therefore, their extraction may generate negative ecological impacts by affecting the structure and functioning of marine ecosystems, as well as negative socioeconomic impacts, by directly or indirectly affecting the income of actors that benefit from the populations of prey, predators or competitors of the target resource (Pikitch *et al*., 2014; Christensen *et al*., 2014b). This is particularly relevant in the Latin American context as artisanal and industrial fishing regularly competes with the target resource, and the extraction of resources for a type of fishery may indirectly impact the other.

The answer to this is to adopt fisheries management with an ecosystem approach. This means incorporating in decision-making processes, considerations on the impact of fisheries activities on the ecosystem and not only on the target resource. This can be undertaken through the application of complex ecological models where the impact is directly evaluated (Christensen *et al*., 204b). For example, it was determined that in the Barents Sea (Arctic Ocean), Capelin (*Mallotus villosus*) was the main prey of codfish (*Gadus morhua*) (Olsen *et al*., 2010). Both cod and Capelin are target species for different industrial fisheries. To prevent the collapse of cod fisheries, Capelin fishing is closed when its biomass falls below 200 thousand tons (Pikitch *et al*., 2014). At present, not one industrial fishery in Latin America has a similar fisheries management mechanism. Even though small pelagic fish (i.e. anchovy and sardines) exploited by industrial fisheries in Chile, Mexico and Peru, comply with ecological roles similar to Capelin (Pikitch *et al*., 2014).

It is important to highlight that the application of complex ecological models to evaluate the ecosystems impact from fisheries is a demanding process that requires massive information, as well as a critical mass of suitably qualified professionals to undertake analysis. Therefore, it is important that research institutions supporting fisheries management at the national and regional levels are adequately funded, as well as continuous training provided for their personnel. Aforementioned digital repositories with multiple complex ecological models are one tool which supports this process.

On the other hand, in order to minimize the negative impact of fishing on marine ecosystems, it is also important to prevent and mitigate by-catch –by-catch of different species than target species (Rochet *et al*., 2014). Unfortunately, the selectivity of main fishing methods in Latin America is limited. For example, in Mexico, industrial trawling captures one ton of shrimp for every ten tons of by-catch and the country still lacks tangible measures to prevent and mitigate their impact (Cisneros-Montemayor *et al*., 2013).

Fisheries in countries like Canada and New Zealand have successfully managed to reduce by-catch, by implementing an Individual Transferable Quota System for by-catch (O'Keefe *et al*., 2014). In these cases, vessels exceeding their individual quota of by-catch before capturing their individual quota of the target resource are banned from conducting fishing activities. As a result, they either discontinue fishing or proceed to buy part of the by-catch quota from other vessels. This system has encouraged vessels to be more selective and not exceed the total by-catch quota (O'Keefe *et al*., 2014).

Nevertheless, such policies require a strong rule of law; the commitment by users and important public investments to define and monitor the compliance of by-catch individual quotas. This might limit its effectiveness in the current context of Latin America.

Alternatively, Chilean and Peruvian legal frameworks have measure to reduce by-catch based on the zoning of fishing areas. Both countries prevent industrial fishing within the first five miles of their EEZ. This is due to the poor selectivity of purse seines and industrial trawling, and the high ecological value as a fish and invertebrate breeding zone of the marine area nearest to the coast (Seitz *et al*., 2014). When defining the exclusion area for industrial fishing it is of dual function: to reduce the probability of by-catch, mainly species exploited by artisanal fishing, and prevent trawling over the seabed, damaging the associated biodiversity.

On the other hand, Peru has opted to include by-catch tolerance percentages in their Fisheries Management Regulations. Theoretically, these could be used to temporarily close fishing zones that register by-catch in excess to tolerance percentages, or to close fisheries when their vessels have registered by-catch above the amount as a result from multiplying tolerance percentages and the target resource quota. However, there is no evidence on the use of these percentages as reference points for fisheries management or by-catch prevention. They are alternatively used to sanction vessels whose landings of non-target resources exceed such percentages; a situation that may be encouraging discards, the practice of returning unwanted catches to the sea, either dead or alive.

Discard conceals the by-catch, not allowing an adequate quantification of the impact fisheries have on marine ecosystems (Pauly, 2009; Pauly and Zeller, 2016. Therefore, Chile has promulgated six management plans that seek the reduction of discard at different industrial fisheries (SUBPESCA, 2017). These management plans also encourage the implementation of fisheries practices that prevent or reduce by-catch, placing Chile as one of the most committed countries to the reduction of by-catch in Latin America (Sapag *et al*., 2016).

Towards good fisheries governance

Good governance is one of the most important factors for the effective, responsible and equitable management of natural resources and, in this particular case, to guarantee sustainable management of industrial fisheries and minimize the potential negative impact this type of fishery generates on ecosystems where they develop. Governance is understood not as a synonym of government, but as the interaction and collaboration among governing institutions and citizens in decision-making processes (Graham *et al*., 2003).

Good governance should be effective, equitable, proactive, robust, dynamic and adaptive (Bennett & Satterfield, 2018). In terms of fisheries, this requires (De la Puente *et al*., 2011): a) a legal framework that explicitly incorporates management objectives and details decision-making processes (i.e. how to define a catch quota and how to assign a portion of it to a vessel or ship-owner); b) solid institutions whose roles have been clearly detailed, defining spaces for citizen participation and conflict resolution mechanisms; c) supervision and sanction systems that would guarantee the implementation of agreed standards (i.e. prevent the systemic and reiterative non-compliance of the legal framework) and learning from the institutions in charge of fisheries management; d) continuous research to address the information needs required for fisheries management and reduce uncertainty; and e) monitoring and assessment systems that would measure management performance in relation to their objectives, in order to adapt legal and institutional frameworks linked to management in a timely manner.

Chile is the country in Latin America that has advanced the most in terms of fisheries management. Through the New Law on Fisheries (No. 123), Fisheries Scientific Committees and Management Committees were created. The Fisheries Scientific Committees are participative spaces aimed towards determining the situational state of fisheries, the biological reference points and ranks in which general catch quotas can be set (BCN, 2014). Thus, Chile seeks to separate scientific processes related to fisheries management from political pressures that violate them, generally associated to employment or economic growth factors.

On the other hand, Management Committees are consultancy and or advisory bodies of the fisheries authority, made up of key sectorial representatives of each fishery (artisanal and industrial), as well as representatives of SUBPESCA AND SERNAPESCA. These Committees can be directed at (i) closed access fisheries, in incipient recovery or development, and (ii) at benthic resources fisheries. The Committees are in charge of designing, evaluating and implementing management plans, aimed towards the establishment of norms and actions to permit fisheries administration within the framework of resource sustainability and conservation. By 2019 there are 33 operative management committees that have approved 18 management plans.

On the other hand, a common challenge for Latin American countries is to endow research institutions with sufficient resources and autonomy. Therefore, their research plans and budgets must be aligned with each other, relying on financial security in order to prevent: ruptures in the continuity of research efforts for such institutions, and/or changes in research priorities due to the replacement of government authorities, or variations in external donors funding priorities.

Furthermore, fisheries governance systems and institutions involved must be capable of facing the challenges and opportunities brought by climate change. As has been discussed, climate change is affecting the structure and functioning of marine ecosystems, generating variations in their productivity and stability at a global level (Cheung *et al*., 2009; 2010; Sumaila *et al*., 2011). For this reason, it has been recognized that at present, sustainable management of resources (allowing the recovery of overexploited stocks) is the best and most effective climate change

adaptation measure in terms of fishery (Sumaila *et al*., 2012). To this end, it is crucial to have fisheries management systems with an ecosystem approach, articulated within effective and dynamic governance systems (adaptive and proactive) (Pauly *et al*., 2002; Allison *et al*., 2009; Sumaila *et al*., 2012; Miller *et al*., 2013; Bennett & Satterfield, 2018).

Conclusions and recommendations

- As seen throughout this document, the oceans are essential for human life, as we know it today. In particular, healthy oceans allow fisheries activities, of crucial importance for the well-being of coastal communities and food security for millions of people at a worldwide scale. Unfortunately, these activities have been developing in increasingly vulnerable and less predictable marine ecosystems. This is either due to the overexploitation of resources, the degradation of marine ecosystems or the effects of climate change; we are at a breaking point that requires immediate changes and actions to ensure the sustainable development of our oceans.

- In order to ensure responsible and sustainable fisheries management within a Blue Economy, effective and participative management and governance mechanisms need to be established. Throughout this document, we have presented the challenges that need to be surpassed in order to move towards responsible artisanal and industrial fisheries management. In the first place, achieve the sustainable management of target resources. To this effect, it is essential that resources exploitation rates are determined based on biological reference points that include ecosystem variability and dynamism. The second challenge is fisheries management with an ecosystem approach. In order to meet this challenge, the decision-making process must be based on a quantitative analysis of the combined impact of different fisheries on the various ecosystem components, incorporating the best available science and precautionary approach in the light of uncertainty. Finally, we highlight the importance of good fisheries governance. This must be effective, equitable, proactive, robust, dynamic and adaptive.

- It is important to remember that fishing does not happen in an isolated context of other economic activities and/or interests. Therefore, in order to improve the quality of life for people, prevent conflicts, face climate change and minimize the overexploitation of living marine resources, it is important to contextualize the development of economic activities in coastal-marine ecosystems, within the framework of the Blue Economy. A first step towards achieving this would be the establishment of communication channels among diverse users and the administrators of such ecosystems. Effective communication generates confidence and respect among actors, encourages joint work and strengthens governance systems. Likewise, tools such as marine spatial planning and marine protected areas play a key role in the conservation and management of marine ecosystems, and should be developed more in the Latin American and Peruvian context.

- Lastly, fishery is a highly important economic activity at the world level and in the region. In spite of the present state of fisheries resources and the uncertainty brought on by climate change, it is important to point out that implementing resources sustainable management under an ecosystem approach, would allow its recovery and development in perpetuity. It means that this activity still has the potential to increase in the near future, its contribution to employment, income and food security.

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