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STATE OF GLOBAL FISHERIES – TRENDS AND PREDICTIONS

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Abstract

As human population on Earth has just reached seven billion, food, freshwater and energy supplies are of increasing concern. With fisheries supporting hundreds of millions livelihoods and most of the global capture fisheries production coming from the marine environment, sustainable management of fishing activity based on sound scientific data and reasonable predictions is one of the major issues we face these days. Literature review of the most recent publications on the state of global fisheries was conducted and ten main trends were identified, including expansion of fishing to new ecosystems and species, decline in landings, increase in fishing effort, growth of aquaculture and changes in the abundance and distribution of species. Issues with predicting the future were discussed, as well as usefulness of computer models and possible recovery of the ecosystem.

Key words: overfishing, ecosystem, models, food security, Ecopath

Introduction

Fishing can be traced back to 2000 B.C., when it first appeared in Aboriginal art rock paintings (Chaloupka, 1993). For hundreds of years, people perceived oceans as endless – endless travelling, endless food supply, endless tourist attraction and endless waste water sink. However, with population increase and start of commercial fishing, problems with environmental pollution and destroying fisheries arose. Since the Industrial Revolution and the technological improvements in acoustics, trawling, processing and communication in 1950-1970s, a constant increase in efficiency occurs. Not much increase in fishing effort was observed until 1970s, but from then on there has been an increase of about 1% annually, recently driven strongly by Asia (Anticamara et al., 2011). However, technological improvements in efficiency were not followed by sustainable management strategies. First stock collapses were observed in 1971 and 1972 of Peruvian anchovies and in 1990s of cod in east Canada and New England

(Pauly et al., 2002). Since 1980s there has been a decline in landings, currently about 500 000 tonnes per year (Pauly et al., 2002; Pauly et al., 2003).

An important problem with assessing the state of fisheries is our changing baselines – what constituted a poor catch for our great grandparents may be perceived by us as an exceptionally good catch. Although fisheries have been a source of food and income for hundreds of years now, there are not many datasets offering the number and types of active vessels, landings and bycatch sizes, fishing effort and aquatic food supplies statistics over the years. Most of the data that is available, comes from reported catches and registration systems, not scientific research. Another important issue is the problem of illegal, unreported and unregistered catches (IUU) where only estimations are available and their uncertainty is substantial.

During the last 15 years many studies regarding the state of fisheries were published, most of them focusing on one aspect of the issue, like food security or abundance of a given species, or modelling scenarios for the future. This article is a general overview of the current state of fisheries, bringing together statistics, economy, social sciences and biology to provide a comprehensive, yet concise review of the most recent publications. The second part of the article identifies ten major trends visible in the data, which are likely to continue in the future. The third part describes issues with making predictions, including what should be taken into account when discussing the future of fisheries, problems with using computer models, predictions regarding climate change and recovery of the ecosystem.

1. Current state of fisheries

In 2008, fisheries production was estimated to be 142 million tonnes, of which 80 million were from marine capture fisheries (FAO, 2010). The highest production of marine capture fisheries, 86.3 million tonnes, was noted in 1996 and decreased to 79.5 million tonnes in 2008. 53% of marine fish stock groups are fully exploited and 32% overexploited, which is the most concerning result since mid-1970s when large-scale observations started. Brown (2011) stated that overfishing is best documented for benthic fish and coastal ecosystems due to ease with which these areas are explored. Moreover, as an 80% decline in community biomass of a given fishery is estimated within 15 years of beginning its exploitation (Ransom & Worm, 2003), it can be predicated that these data will gradually get worse as the most recent peak in fish harvest occurred in 2004 (FAO, 2010). Only 1% of fisheries show signs of recovery.

In 2010, the global fishing effort was reported as 4.3 million vessels (FAO, 2010) and 4.4 billion kilowatt days (total engine power and number of fishing days in a year), which is a 54% increase compared to 1950s (Anticamara et al., 2011). It is exceeding the optimum by a factor of 3 to 4 (Pauly et al., 2002). Vessels of 100-149.9 grt (Gross Register Tonnage class 5) dominate global fishing, yielding 2.7 billion kilowatt days (Anticamara et al., 2011). The highest fishing effort is exerted by trawlers – 2.2 billion kilowatt days. Europe has the highest number of fishing vessels of more than 100t, but Asia has most vessels overall – 75% of motorized fishing vessels and 77% of other types of vessels (FAO, 2010). In Europe, Russian fishing effort is the highest, followed by Spain, United Kingdom and Portugal. However, total European Union effort exceeds that of Russia. China dominates Asian fishing effort and United States and Canada dominate North American effort. As for South America, Argentinian, Brazilian and Venezuelan efforts are the highest, while New Zealand and Australia dominate fishing effort in Oceania and Mozambique, Morocco and Egypt in Africa. The main consumers of fish are European Union, the United States of America and Japan.

1.1. Fisheries and global economy

Fisheries and aquaculture typically represent 0.5-2.5% of GDP, but in some countries it may exceed 7% (Garcia and Rosenberg, 2010). The estimated first-sale value of global capture fisheries production in 2008 was $93.9 billion (FAO, 2010). Trade in fishery products forms about 10% of total agricultural exports, which is 25% increase since 1970s, and 1% of world merchandise trade. Biggest fishery products exporters are China, Norway and Thailand and the total world export value reached $102 billion in 2008, which in real terms is 50% increase since 1998. Japan, the United States of America and the European Union are biggest fishery products importers and the total world import value was $107.1 billion in 2008, 9% increase compared to 2007.

It is estimated that fisheries, aquaculture and related activities support more than 540 million livelihoods (FAO, 2010). About 44.9 million people work directly in this sector, which is 1.4% of people economically active worldwide and a 167% increase from 1980s. Growth in the sector employment relies mostly on small scale activities. In less economically developed countries average annual production per person is lower than that in more economically developed countries – about 2.4 tonnes compared to 24 tonnes for fisheries and about 2 tonnes compared to 172 tonnes for aquaculture. This represents the differences in fishing methods and scales – high tech, large vessels employ fewer fisherman than low tech, small vessels for the same catch size.

Fisheries seem especially important to less economically developed countries – it is not only a source of income, but also foreign currency and only source of protein in diet (Garcia and Rosenberg, 2010). However, with increasing demand from international markets, there is a serious threat of encouraging IUU and destructive fishing, export of fish at the cost of local food security and corruption (Swartz et al., 2010).

In more economically developed countries, globalisation caused increased demand and powerful competition (Swartz et al., 2010). Demand for fish shifted towards high value species – usually shrimps and top predators. Employment in the fisheries sector is declining, due to introduction of fisheries management policies, such as landing quotas, powerful competition from less economically developed countries, introduction of new, less labour intensive technologies and stock collapses. Outsourcing processing activities, like filleting and packaging, to less economically developed countries is an often practise (FAO, 2010), which can also influence the employment level in more economically developed countries.

1.2 Fisheries and food security

Fisheries contribute to food security in two ways: producing food and providing a source of income to buy other food (Garcia and Rosenberg, 2010). Fish meat is healthy – as it contains lots of protein, micronutrients, minerals and essential fatty acids, it is a highly valuable resource, especially for animal protein deficient or cereal-based diets. More than 4.5 billion people get over 15% of their animal protein intake from fish (FAO, 2010) and over 400 million people depend critically on fish for protein in their diet (Worldfish, 2009). Countries that are especially dependent on fish as a food source are island countries and less economically developed countries, such as Bangladesh, Ghana, Vietnam, Cambodia and Burma (Hortle, 2007; Laurenti, 2007). From 144 million tonnes produced in 2006, 110 million tonnes were used directly as food, while 34 million tonnes were used for food for cattle, pigs, poultry, fur animals and aquaculture (Garcia and Rosenberg, 2010; FAO 2010).

1.3 Fisheries and the ecosystem

About 30% of marine capture fisheries production relies on just ten species – most stocks of anchoveta (*Engraulis ringens*) in the Southeast Pacific, Alaska pollock (*Theragra chalcogramma*) in the North Pacific, blue whiting (*Micromesistius poutassou*) in the Atlantic, Atlantic herring (*Clupea harengus*), Japanese anchovy (*Engraulis japonicus*) in the Northwest Pacific, Chilean jack mackerel (*Trachurus murphyi*) in the Southeast Pacific and largehead hairtail (*Trichiurus lepturus*) in the Northwest Pacific, as well as 95% of tuna species stocks are fully exploited or depleted (FAO, 2010). Large predators, like tuna, marlin, sharks, swordfish, are a major concern – not only they grow slowly and are heavily fished due to high market price, but also it is difficult to assess their population and the impact of fishing due to their huge habitat and tendency to live at low densities (Brown, 2011).

Worm and Tittensor (2011) studied geographic ranges of 13 species of tuna and billfish based on catch data presence or absence in different regions. Their work showed that ranges of 9 species have contracted and 2 species – expanded. This suggests that not only species abundance changes due to human fishing activities, but also species distribution, which suggests that recovery of ecosystems may take longer than expected (Brown, 2011).

Fisheries also have a negative impact on non-target species and the environment – problems like ghostfishing, changes in food webs, bycatch, discard and destruction of habitats by trawlers are a major concern. Discards of bycatch were estimated at 9.5 million tonnes (Kelleher, 2005). 35% of global primary production is used to sustain fisheries and the mean global trophic level is about 3.2 and has been declining 0.05-0.10 per decade (Pauly et al., 2002). Removal of predators changes the food web by causing an increase in populations of previously suppressed species, like jellyfish (Pauly et al., 2009), simplifying it, decreasing its buffering capacity, increasing variability and unpredictability of landings and fish sizes and increasing the impact of the environment on fisheries resources (Pauly et al., 2002).

2. Trends to extrapolate

The main factor that will influence the demand for fish products and so influence the state of fisheries is population increase. With constant improvement of living standards, it seems safe to assume that the human population will continue to grow in the future. Currently, half of the population lives within 60 km of the ocean and ¾ of large cities are located by the coast (Garcia and Rosenberg, 2010). This trend is expected to continue with 60% of population living in coastal areas by 2060 (Kennish, 2002). With depletion of stocks, our baselines will also continue to change (Pauly et al., 2005).

2.1 Stocks, landings and species

The depletion of current stocks means that fishing will have to expand to new ecosystems, choose new species and implement new technologies. As continental shelf is only 7% of the global ocean, expanding fisheries to new stocks and deeper waters seems inevitable (Pauly et al., 2002; Pauly et al., 2003). However, exploring deep slopes, canyons, seamounts and deep-ocean ridges, especially by trawlers, requires a lot of energy, thus with increasing prices of fossil fuels, exploitation of those habitats may become cost inefficient.

Global fisheries landings are declining and the trend is expected to continue, at the rate of about 500 000 tonnes per year (Pauly et al., 2003). Due to constant overfishing and inevitable stock collapses, even with improved fish detection technology it might be not possible to supply as much fish products as before. Unfortunately no precise IUU landings trends are known due to lack of reliable data (Agnew et al., 2009), but catches are expected to increase due to growing population, prices and demand for fish (Garcia and Rosenberg, 2010).

2.2 Species

Fishing industry will have to adapt to decreasing stocks of top ten species – large, long-lived fish – and switch to other species, probably mesopredators or even herbivores. This “fishing down the food web” would further decrease the mean trophic level and change the structure of food webs.

Catches of crustaceans and cephalopods are expected to continue increasing (Garcia and Rosenberg, 2010), mostly due to removal of their predators. The only two major resources that could be developed are krill and cephalopods, however those are needed by large marine predators and their removal would bring enormous changes in the global and local food webs.

2.3 Fishing effort

Fishing effort has increased about 1.1% annually since 1960s, mostly because of Europe, and more recently, Asia (Anticamara et al., 2011). Currently, Asian fishing effort is about to approach that of Europe and based on continuous economic growth in China, it may increase further, exceeding European effort. This may also mean a change in the number and type of registered vessels – fishing effort of GRT class 2 (1-24.9 grt) will probably continue to increase as most of these vessels are registered in Asia.

2.4 Employment

Employment in fisheries in economically developed countries is decreasing, about 11% compared with 1990s (FAO, 2010), and this trend is also expected to continue due to reasons described above. This may lead to political pressure to stop environment protection programmes and to continue, or introduce, subsidies, increase in IUU and destructive fishing (Garcia and Rosenberg, 2010), social tensions, higher local and national unemployment rates and increased spending on social services. Garcia and Rosenberg (2010) suggested that the society and non-governmental organizations should work on raising awareness of the issue, develop new non-fishery jobs, provide training and assist the poorest of the sector.

2.5 Ecosystem changes

As already observed, species abundance and distribution will continue to change because of direct human impact, like overfishing, and indirect human impact, like mesopredator release caused by removal of top predators. Abundance of species will probably continue to decline, as it is highly unlikely that fishing will be ceased any time soon. As described by Worm and Tittensor (2011), shift ranges will continue as well, as some fish species are removed by human activity and other species can increase their population due to removal of their predator. These abundance and range changes are very likely to influence the food web as well.

2.6 Aquaculture

Aquaculture grows faster than any other food-producing sector and is predicted to supply over 50% of aquatic food by 2015 (Bostock et al., 2010). As with fishing effort, this will probably remain driven by China, as their aquaculture production accounts for 62% of global production by quantity and 51% by value (FAO, 2010). However, as food for aquacultures is usually provided by capture fisheries, with declining stocks and increase in fish product prices, there are two routes aquaculture may follow: either producing high value carnivores or low value herbivores (Garcia and Grainger, 2005).

3. Predictions, models and climate change

There are two ways to predict the future of fisheries – to extrapolate the trends that already exist, as presented above, or to model possible scenarios. Both methods are not free from mistakes, base on assumptions and should be treated with caution.

The major problem with predicting the future is lack of data. Most of the distribution and abundance data comes from reported catches, not scientific observations and measurements. From all exploited fish stocks, only about 10% are assessed, but not frequently or regularly (FAO, 2010). There are known cases of overreporting and underreporting landings and fishing effort data is often patchy, non existent or inaccessible (FAO 2010; Anticamara et al., 2010).

Reported catches do not include IUU fishing and for the purpose of biological and ecological research, bycatch and discard data is as important as landings data.

According to Garcia and Rosenberg (2010), when predicting the future of fisheries, the diversity of the sector should be considered: scale of technology (small fisheries, large fisheries), business organisation (family-run, corporate), objectives (subsistence fisheries – source of food; reduction fisheries – fish oil and meat; commercial fisheries – supply of markets; sport fisheries – recreation), target resources (high value, low value; top predators, mesopredators, herbivores; bottom fish, pelagic fish), type of jurisdiction (regional, national, international, Exclusive Economic Zone, high seas), location in production chain (capture, processing, distribution), supporting activities (maintenance, provisioning) and landing base (rural, urban). However, there are no datasets available that would collect, evaluate and give public accesses to that type and amount of data. The most extensive dataset, by Food and Agriculture Organisation of the United Nations (FAO, 2010), which is based on reports from members and disseminated statistics, is still limited – e.g. fishing fleet data obtained in 2009 came from 137 countries, which represents only 67% of countries involved in fishing activities. Also, most of the reports received by FAO are based on national registers, which often tend to underestimate the number of vessels based on the variations of local registry law.

3.1 Climate change

Oceanic climate change means variations of biological, chemical and physical properties of the ocean on a specific time scale. It has recently been noticed that burning up fossil fuels influences the CO_2 levels in the atmosphere and the global temperature. Thus, proportionally, ocean acidification and sea surface temperature are expected to grow as well.

Usually when conducting research, scientists are investigating a specific area at a specific moment or on a relatively short time scale of months, years or a few decades. There are few projects, like NOAA's global temperature anomaly measurements (NOAA, 2010), running for a century and collecting data for the whole world. However, although a century may seem a lot of time for humans, when considering climate change, it is a very short period of time. As the global ocean developed 4200 Ma ago (Cavosie et al., 2005), a century or millennium of data would not be sufficient to advance a theory about a highly significant oceanic climate change. The climate naturally fluctuates-from seasonal variations, El Nino events to ice ages-and looking only at the data from the last century at most, it is extremely easy to fail to notice a natural process which could be responsible for the present climate change. An increase in the temperature and carbon dioxide concentration could be just a natural, temporary situation, not a significant change in comparison to the climate history (e.g. glaciation periods). Also, the anthropogenic effect on the climate could coincide which a natural climate change, further increasing the effect.

The time scale problem can be solved by obtaining data for temperature and greenhouse gasses concentration from the past. To do this, a number of methods was developed, for example measuring $\delta^{18}O$ in ice cores. However, these methods are also limited in time scale (from only decades of data to thousands of millennia (Brook, 2007), space scale (they give data for a specific place) and geographical location (ice cannot be found everywhere) (Thompson, 2000). The second limitation could be overcome by taking multiple measurements in many regions of the world, so the best-possible data set could be gathered. In the case of marine ecosystems, it is not possible to gather data from ice cores, so a method using $\delta^{18}O$ records in corals was developed (Tudhope et al., 1995). The skeletal oxygen isotope record in corals depends on the rainfall, which in turn depends on climate. As in the case of ice cores, this method is however limited in space and time scale and geographic location.

One of the most evident examples of problems with space and time scales when considering oceanic climate change are the changes occurring in ecosystem structures. Ecosystem structure is divided into 3 different, but connected levels: biological communities (species present, biomass, life history, etc.), non-living materials (quantity and distribution of nutrients, etc.) and conditions of existence (light, temperature gradient, etc.) (Microbiologyprocedure.com). When any of the physical factors change, all living organisms must adapt to the change or they could become extinct.

Marine organisms live surrounded by water and, as the heat capacity of water is quite high and the chemical composition of seawater is constant, these organisms usually need little regulating abilities and do not adapt easily to the environmental changes. However, this also depends on a specific species (e.g. stenohaline and euryhaline fish species). A notable example here is the temperature tolerance of corals, in which a temperature change of 1-3°C causes bleaching and can lead to coral death and collapse of the reef habitat, which is a breeding and schooling ground for many fish species (Hoegh-Guldberg, 2001).

However, all ecosystems are affected by some fluctuations-e.g. day and night temperature changes, extreme weather events, seasonal nutrient availability, El Nino Southern Oscillation. These changes in conditions of existence and non-living materials cause a change in biological communities. Climate change has the same characteristics, but it affects all ecosystems and for a longer period of time. As ecosystems are complicated in their structure and not yet fully understood, when considering a specific ecosystem structure change, it is very difficult to determine the cause. Natural oscillations of about 55-60 years in ecosystem productivity have also been noticed and have a significant impact on the resources and fisheries (Garcia and Grainger, 2005).

The first problem associated with climate change and ecosystem structure changes is the space scale of the change. As each ecosystem is unique and occupies only a given area, it is not safe to make conclusions for the whole ocean system using data from only one place. The structure change in that place could be either really caused by climate change or by a yet unknown, or overlooked, local factor. Also, unlike in laboratory conditions, it is impossible to control other factors affecting the area and observe only the one that is probably the cause of ecosystem structure change. The risk of reaching incorrect conclusions could be decreased by looking for the same changes in similar ecosystems, but, as each ecosystem is unique, it is not always possible.

The second problem is the time scale. As ecosystems are affected by many processes, it is very difficult to determine the cause of the change, especially if the data is limited to just years or decades-due to lack of data before that or because the ecosystem change has just begun. It the later case, it is especially difficult to predict whether the change is a one-time, temporary anomaly or a beginning of a sustained process. However, if the process of change is a long lasting one and happening in more than one ecosystem, it is very likely that the cause of it is an oceanic climate change.

As long as our understanding of the climate remains at the level it is today, it is extremely difficult to include the effect of climate change on the ecosystem while predicting the future of fisheries. Since the Industrial Revolution, a 0.1 decrease in the pH value was observed (Richardson, 2008), which, together with sea surface temperature change mentioned above, is a trend that can be extrapolated. However, there is no scientific consensus on what that will mean for the ecosystem – even two studies of the same phytoplankton species (*Emiliania huxleyi*) can give completely opposite results (Riebesell et al., 2000; Iglesias-Rodriguez et al., 2008).

3.2 Issues with computer models

Computer models are commonly used to aid predictions and estimate biomass. The traditional models used to assess state of fisheries and set catch limits are based on single species approach (Pauly et al., 2002). An individual species abundance and distribution is assessed with no appreciation of its interactions with and dependence on other species in the form of food web. This leads to a model that is based on limited data, many assumptions and does not depict the real situation well. Single species models also require explicit knowledge on current stock status and total withdrawal from stocks, which are prone to error, as described above.

In 2009, Howell et al. demonstrated the usefulness of the free Ecopath with Ecosim software (EwE) in modelling ecosystems as a part of the DEEPFISH Project. This type of software tries to take into account the complexity of the ecosystem and allows predictions of the effect fishing activity has on the biomass of a given ecosystem.

The usefulness of every model and further simulations should be considered based on what the input data was. It is important to note that the input data includes all species, their biomass, diet, reproduction and growth rate, nutrient limitation and presence and activity of all fishing fleets. As in every study, data quality is crucial – the more studies are used, the more precise the model. It does allow some level of flexibility, if not all information is available, but accuracy of the model will be affected. Like every model, EwE predictions can and should be verified using historical or real studies data – as shown by Howell *et al.* (2009).

There are however several issues that have to be considered when using EwE models. First of all, the model assumes uniform distribution of species/individuals in the given area, which is usually not true. For example, zooplankton undergoes daily vertical migration and is distributed in patches, North East Atlantic blue lings (*Molva dypterygia)* form aggregations around seamounts and orange roughies (*Hoplostethus atlanticus)* migrate between feeding and spawning sites. Also, the model describes mortality as predation (including fishing) and minor mortality factors (disease, old age), but does not account for mortality due to unexpected events, like epidemics, pollution or introduction of alien species. Predation is influenced by the size of fish, which is not included in the model. Moreover, there is no indication of seasonal variations, which, even at higher depths, still influences the ecosystem through changing phytoplankton biomass. All simulations should therefore be considered alongside migration, biodiversity, pollution and climate change data and any data analysis should be carried with a good understanding of the biology of the species involved.

Like any generalisation and mathematical representation of the complexity of nature, software packages like EwE should be used with care and understanding of the ecosystem and species involved. When used properly, it is a very useful tool and can provide a good overview of how fishing effort changes the food web, but if used not carefully enough, especially by policy makers, it can be a threat to sustainable management and development of fisheries.

3.3 Recovery

A recent article by Frank et al. (2011) shows that worries of permanently destroying ecosystems by removing predator fish might not be justified. They studied changes in the population of 15 commercially exploited fish species, including cod, haddock, Greenland halibut and long fin hake, prior and during intensive fishing (annual biomass removals of >50%) and after introducing strict management plans on Scotian Shelf. Although at first no recovery was observed, due to predator-prey reversal, after 13 years and two transition stages, benthic fish biomass reached pre-collapse levels. Frank et al. described the processes the ecosystem went through and proposed reasons for these changes. They concluded, that given enough time and no events that could inhibit the recovery process, like jellyfish blooms, even severe changes to ecosystems are fully reversible. However, at the time of their research, the average weight of predator species, as well as cod to haddock ratio, did not match relevant pre-overfishing values, which makes their predictions about full recovery slightly too early.

Although using very extensive data sets and robust statistical analysis, several points regarding Frank et al. methodology could be raised. Firstly, no environmental factors other than temperature and density were analysed and their major data set covered only summer months. As other factors, such as pollution and nutrient depletion (Shelton et al., 2006) could have influenced the data, more research should be conducted towards factors influencing food webs already altered by overfishing. Perhaps looking into fish migrations in the region would be useful as well. Also, the authors did not mention any ways in which they accounted for zooplankton patchiness, as taking simple average of vertical haul measurements and multiplying it by area seems insufficient (Folt and Burns, 1998).

Moreover, it is not clear how these conclusions based on a study of a relatively small and homogenous area can relate to other environments, such as freshwater, polluted, of low species diversity or in different climate. There are no publications supporting this study, but several presenting opposite outcomes (Jackson et al., 2001; Pauly et al., 1998). Moreover, no indications of scaling were given, as to whether the effect would still be the same if a larger ecosystem was destroyed.

It seems especially important to look critically at this study, as there is a serious threat of using it in an irresponsible way, especially by often underestimated fishing industry (Pontecorvo, 2008). It can be perceived as a valid argument for cancelling any fishery management quotas, as ecosystems affected by overfishing, according to this research, will eventually recover. Taking into account the reality of business-oriented world, this could present a real threat to Earth's marine biome.

Undoubtedly, more research into anthropogenic ecosystem changes is needed, especially in various regions and types of environments. Frank et al. (2011) presented first study of such breadth with optimistic outlook for future. It shows a need to not only revise re-stocking policies, but also to monitor and discuss ecosystem dynamics on a worldwide scale.

Conclusions

The current state of fisheries appears to be a result of our endless approach to the oceans, changing baselines, population increase and poor, or non existent, management of fishing activity. Most marine fish stock groups are exploited, human activity caused changes in the ecosystem and there are not many possibilities to switch to other marine species. Fisheries and related activities form an important part of the global economy, especially for less economically developed countries. Fish meat is an exceptionally valuable food resource and many people are fully dependent on – both as their source of protein and income.

The following trends were identified in the literature review and are expected to continue, given that no immediate action is taken to protect the fisheries or control fishing activity in the upcoming years:

- Expansion of fisheries
- Decline in landings
- Increase in fishing effort, especially due to Asia
- Increase in number of GRT class 2 vessels
- Increase in IUU fishing activity
- Abundance changes
- Range shifts
- Increase in cephalopod and crustacean catches
- Growth of aquaculture
- Decrease in employment in the fisheries sector

Although this is not an exhaustive list of trends that were visible in the literature, these aspects seem to be the major issues that should be discussed and taken into consideration by fisherman, fishing activity organisations, policy makers, NGOs and environment protection groups.

The major issue with making any predictions about the state of fisheries in the future is lack of high quality, scientific data, especially regarding regular stock assessments and IUU fishing activities. In the case of computer models, it is also very important to evaluate and support any results with a sound biological and ecological knowledge to interpret the possible scenarios correctly.

Climate change is another important challenge, which should be tackled by conducting research on the very basics – how changes in the atmosphere affect the biology, chemistry and physics of the ocean and how these effects influence the primary production that supports the whole ecosystem. Without a good understanding of phytoplankton response to climate change, it is extremely difficult to predict how the ecosystem and fisheries may change. Moreover, more research on the recovery of once exploited ecosystems seems crucial in the upcoming years. Together with an extensive dataset on the historical and current state of fisheries, good understanding of climate change and useful computer models, it would be an invaluable resource to develop and implement plans for sustainable management of fisheries and protection of the marine ecosystem.

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STAN RYBOŁÓWSTWA NA ŚWIECIE – TRENDY I PROGNOZY

Streszczenie

Populacja ludzka na Ziemi osiągnęła poziom siedmiu miliardów osób. Zapewnienie dostaw żywności, energii i słodkiej wody dla wciąż rosnącej liczby ludności staje się coraz większym problemem. W związku z tym, że rybołówstwo jest źródłem utrzymania setek milionów osób, a większość światowej produkcji pochodzi ze środowiska morskiego, zrównoważone zarządzanie działalnością połowową w oparciu o rzetelne dane naukowe i wiarygodne prognozy jest jednym z najważniejszych zadań, przed którymi współcześnie stoi ludzkość. Na podstawie przeglądu najnowszych publikacji na temat stanu światowych połowów zidentyfikowano dziesięć głównych kierunków zmian, w tym ekspansję połowów na nowe ekosystemy i gatunki, spadek połowów, wzrost nakładów na rybołówstwo, wzrost akwakultury oraz zmiany w wielkości populacji i rozmieszczeniu gatunków. W artykule zostały omówione problemy z prognozowaniem przyszłości rybołówstwa, jak również przydatność modeli komputerowych oraz możliwość poprawy stanu ekosystemu.

Słowa kluczowe: przełowienie, ekosystem, modele, bezpieczeństwo żywnościowe, Ecopath

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