



## *Chapter 20*

# Responsible Harvesting of Deep Sea Resources

**U.Sreedhar**

Research Centre of Central Institute of Fisheries Technology

Andhra University P.O., Visakhapatnam - 530003

*E- mail: usreedhar@rediffmail.com*

## **1.0 Introduction**

Fishing has been an important occupation for mankind since the Palaeolithic period. The fishing industry has taken great strides mainly due to the motorization of crafts, which in turn led to the evolution of active fishing methods such as trawling. The various fishing methods have gradually improved and diversified over the millennia.

Marine capture fisheries play a vital role in India's economy. The sector provides employment and income to nearly two million people. The growth in marine fish production during 1950s and 1970s has been faster as compared to the inland fisheries. However, during 1980s and 1990s, the trend was reversed as the marine fish production had been slow compared to the inland fisheries. During the 1990s the marine fish production has reached a plateau. A quantum jump in catch from the presently exploited grounds and in certain areas upto 200 meter depth is unlikely, since most of the major commercially exploited stocks in these regions are showing signs of over exploitation. But demand for sea food has been growing and the present scenario suggests that the current level of marine fish production from the exploited zone has to be sustained by closely monitoring the landings and the fishing effort and by strictly implementing the scientific management measures.

The fishing effort in the coastal waters started increasing over the years, mainly due to increase in demand and introduction of new technologies. This eventually has led to the decrease in per boat catch. The erroneous belief in the inexhaustibility of the coastal fishery resources has largely ended and, this threatens the world's food security especially the

animal protein supply, in developing countries. This is where the alternative fishery resources come in to the scenario. In India introduction of deep sea fishing fleet of resource specific fishing vessels such as tuna long-liners, purse-seiners, squid-jiggers etc. is necessary in the present circumstances. These vessels would operate strictly in off-shore zones in Exclusive Economic Zone (EEZ) as well as beyond in the international waters. There would be no scope of conflict with the traditional sector. However, such deep sea fishing fleet would be capital intensive and need to be encouraged through foreign equity participation as well through technology transfer. The development of deep sea fishery industry is of concern to the entire marine fishery sector because it would have considerable impact on the management of near-shore fisheries, shore-based infrastructure utilisation and post-harvest activities, both for domestic marketing and export. This paper briefly describes deep-sea fishery resources, reviews aspects of their sustainability, and discusses alternative strategies for sustainable exploitation.

## **2.0 The Fishery**

Deep-sea fisheries are those that take place at great depths (up to 1600 meters). Many deep-sea fisheries take place in waters beyond national jurisdiction (such as the exclusive economic zone [EEZ]). The great depths and distances from the coast at which marine living resources are caught by deep-sea fisheries in the high seas pose scientific and technical challenges, particularly in providing scientific support for management. A number of governmental and non-governmental organizations with mandates relating to conservation of the environment, biodiversity and management of fisheries have expressed concerns about the likely, known or feared consequences of deep-sea fishing in terms of its effects and impacts on target stocks, associated species and habitats. These concerns are reflected in resolutions adopted by the United Nations General Assembly and led to the adoption of specific recommendations by the FAO Committee on Fisheries at its twenty-seventh session, in March 2007, which prompted the subsequent development and adoption (in August 2008) of the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas.

## **3.0 History**

Small-scale deep-sea fisheries using hooks and lines developed in the early 1800s while trawl fisheries for deep-sea species using factory freezer trawlers started in the mid- 1950s. With the extension of EEZs, starting in the 1970s, several fleets no longer had access to coastal or near-shore fishing grounds; some simply ceased operations while others began developing deep-sea fisheries in the high seas. Since the mid-1990s, the reduction of fish stocks inside EEZs, quota limits and technological advances have increasingly led vessel operators to seek alternative fishing opportunities outside EEZs. Until the last few decades, there has been little activity or interest in deeper waters, apart from the occasional ventures by scientists. During recent decades deep-sea fisheries continues to be of potential interest to nations where coastal fisheries are totally or over-exploited. Deep-sea fisheries on the upper continental slope (~ 600 m) have been developed and are today an important

component of commercial fisheries in a number of countries. This industry is well flourished in developed countries and continents like Europe, Soviet, USA, Canada, New Zealand and Australia. Some of the popular deep-sea fisheries across these nations are, orange roughy (*Hoplostethus atlanticus*), oreos (*Allocyttus niger*, *Pseudocyttus maculatus*), roundnose grenadier (*Coryphaenoides rupestris*), rough head grenadier (*Macrourus berglax*), blue ling (*Molva dypterygia*), black scabbard fish (*Aphanopus carbo*), redfish (*Sebastes mentella*, *S. marinus*), Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water dogfish (*Centroscymnus coelolepis*) Norwegian long-line fishery for ling (*Molva molva*) and the Spanish deep-water long-line fisheries for forkbeard (*Phycis blennoides*) and common mora (*Mora moro*). The commercially exploited deep-water crustaceans include species such as the red shrimp (*Aristeus antennatus*), the giant red shrimp (*Aristeomorpha foliacea*) and Norway lobster (*Nephrops norvegicus*) from the Mediterranean and adjacent seas.

#### **4.0 Fishing Gear**

Longlines, bottom trawls, mid-water trawls, gillnets and traps/pots are used in deep-sea fisheries in the high seas. Trawling is the predominant bottom fishing method, representing nearly 70 percent of vessels in the high seas. Some fisheries, such as those for orange roughy (*Hoplostethus atlanticus*), generally use technologically advanced fish detection and net monitoring equipment: in these aimed-trawling fisheries, the trawl gear may hardly touch the bottom, while other deep-sea trawl fisheries require the trawl to make bottom contact for several hours.

The sea floor is covered by vast plains of soft sediments made up of fine detritus and particles that drift down from the surface. It is the largest habitat on earth where deep-demersal fish comprise about 6.4% of the total number of species of fishes that are known. The deep-sea environment is dark, cold and less productive. The distribution, habits and physiology of deep-sea organisms are influenced by the typical environmental conditions of the habitat. The chief physical factors that affect the ichthyofauna in the deep-sea are temperature, light, pressure, ocean floor and the currents. Salinity and the amount of dissolved oxygen are the main chemical factors that may influence the distribution of fishes. Beyond physical and chemical factors, biological factors also play a key role in the distribution of different faunal assemblages, which include resource availability, predator-prey relationships, and interspecific competition. Fishes that live in this complex environment usually develop different physical and physiological adaptations. A large portion of deep-sea high seas catch is taken in the North Atlantic. In the North East Atlantic, for example, vessels will typically target a range of species, such as ling (*Molva dypterygia*), Greenland halibut (*Reinhardtius hippoglossoides*), roundnose grenadier (*Coryphaenoides rupestris*), black scabbardfish (*Aphanopus carbo*), a few species of sharks and more recently exploited species such as Baird's slickhead (*Alepocephalus bairdii*) and deep-sea red crab (*Chaceon affinis*). The majority of deep-sea fisheries in this area involve bottom trawlers which may operate mid-water trawls as well, but longliners are also present in smaller numbers. In other regions, the vessels target a much more limited number of species, for example in the Southern Ocean

where the fisheries (using longlines) are mainly targeting toothfish (*Dissostichus eleginoides* and *D. mawsoni*). In the South Pacific and the Indian Ocean many of the bottom fisheries take place over rough geological features (e.g. seamounts and ridges). Bottom trawling for orange roughy is generally done as aimed-trawling. Mid-water trawlers, which may operate nets close to the seabed, mainly target alfonsino (*Beryx splendens*). Longliners in the South Pacific typically target species such as hapuka (*Polyprion* spp.), bluenose warehou (*Hyperoglyphe antarctica*) and morwongs (*Nemadactylus* spp.).

## 5.0 Contribution of CIFT

Studies were undertaken by CIFT in various cruises of FORV Sagar Sampada. Sampling was carried out using EXPO model fish trawl and High speed demersal trawl (CV). Stocks were estimated latitude wise and depth wise along the continental slope of East and West coast of Indian EEZ. Eels consisting of *Bathyyuroconger braueri*, *Coloconger rancieps*, *Gavialiceps taeniola* and *Evermannell indica* dominated the catches. *Echinorhinus brucus* (Bramble shark) and the broad nose cat shark (*Apristurus investigatoris*), formed two other major species caught. Other moderately abundant groups were Moridae and Chlorophthalamidae. Chlorophthalamidae consisted of *Chlorophthalamus bicornis* and *C. punctatus*. The species that were caught beyond 700m depth are mainly *Lamprogrammus exutus*, *Gaviliceps taeniola*, *Echinorhinus brucus* and *Hydrologus africanus*. Some of the deep sea non-conventional fish species which figured in the catches were *Priacanthus hamrur*, *Chlorophthalamus agassizi*, *Neopenula orientalis* and *Rexea prometheoides* and were identified as potential unconventional food resources, but value added products need to be developed from these resources. Certain species landed predominantly beyond 500 m in Indian territorial waters are *Myctophum* spp., *B. vicinus*, *Halielutaea* sp., *B. moresbyi*, *C. macrolophus*, *A. bicolor*, *Lophiomus* sp., *B. caudimaculata*, *L. exutus*, *C. rancieps*, *Uranoscopus* sp., *N. pinnata*, *P. cyanea*, *E. radcliffei* and *Luciobrotula* spp.

## 6.0 Vulnerability of the habitat

Fishing can have a negative impact not only on living marine resources but also on related ecosystems. Species groups, communities or habitats that are easily damaged and take a long time to recover are considered vulnerable. The vulnerability of an ecosystem is related to the vulnerability of its constituent populations, communities or habitats. Features of an ecosystem may be physically vulnerable (i.e. structural elements of the ecosystem may be damaged through direct contact by fishing gear) or functionally vulnerable (i.e. selective removal of a species may change the manner in which the ecosystem functions). The most vulnerable ecosystems are those that are both easily disturbed and slow to recover. Examples of species groups and communities that are considered sensitive and potentially vulnerable include certain coldwater corals and hydroids, some types of sponge-dominated communities and seep or vent communities comprised of unique invertebrate and microbial species. These species and communities may be associated with submerged edges and slopes of the continental shelf, summits and flanks of seamounts, guyots, banks, knolls, and hills, canyons and trenches, hydrothermal vents and cold seeps. The ecological characteristics of

deep water fishes can make them vulnerable to over-exploitation, and slow to recover from it. The deep-sea species often have a slow growth rate, high longevity, low fecundity, and hence low productivity. The history of orange roughy fisheries in New Zealand and Australia illustrates the rapid development to a relatively high level, and then an equally dramatic decline. The black scabbard fish (*Aphanopus carbo*) is the target of the oldest deep-sea fishery in the world, which takes place off the island of Madeira, Portugal. For centuries this fishery, which only supplied to the local markets, seemed to be sustainable. However, since the onset of export the fishery expanded and the landings have decreased considerably. However, it is not possible to generalize about biological characteristics, as rubyfish (*Plagiogeneion rubiginosum*) are relatively short-lived and fast growing compared with orange roughy. But, it is widely recognized that deep-sea species are less productive and more vulnerable to fishing pressure than shelf species.

A global review concludes that deep-water fish stocks are "typically fished down, often within 5-10 years, to the point of commercial extinction or very low levels". Another study on fisheries on seamounts worldwide over the previous two decades, concluded that fish stocks associated with seamounts/deep-seas have been consistently exploited at unsustainable levels. The most common reasons given are that there is often little or no understanding of the biology of the target and by-catch fish populations; management measures, where they exist, are often based on poor data; and highly efficient trawl fishing on aggregations of fish on or just above seamounts results in intensive fishing pressure. A common additional problem is the fact that the management regime is either weak or non-existent, a problem which continues today.

## **7.0 Management of deep sea resources**

Several renowned fisheries research institutions from North Atlantic region have undertaken investigations in estimating the biological characteristics and maximum sustainable yields by following standard stock assessment techniques. But, the outcome of basic statistics on catches and effort are of poor quality and in some cases lacking. There is often insufficient information on the general biology of these species, in particular on age and growth, seasonal behaviour, migration, and stock discrimination. These factors always lead to the imprecise stock assessments, which ultimately affect the sustainability of the deep-sea fisheries. This concept was well described in the case of orange roughy based on the New Zealand experience. This uncertainty in fisheries science has, at times, led to insufficient management of resources. The standard management strategies (estimating Maximum Sustainable Yields) applied in several deep-sea fisheries (e.g., orange roughy) has been proven risky and insufficiently conservative.

## **8.0 Future directions**

The types of fishing gear and vessels used in deep-sea fisheries vary greatly, depending on the species targeted and their behaviour. In general, these fisheries are conducted at depths beyond 200 m, on continental slopes or isolated oceanic topographic structures such as

seamounts, ridge systems and banks. Some vessels involved in deep-sea fisheries in the high seas may fish exclusively in the high seas, but others also operate within EEZs during the course of the year, either in deep seas or in shallower waters. Most vessels target several species throughout the year and some regularly change fishing gear. These fisheries are competitive and require a high-level of investment.

The 'ecosystem based management (EBM)' approach is a possible paramount to rescue the deep-sea resources immediately. Various EBM actions now include closed areas, fishing method or gear restrictions, depth limits, catch quotas, by-catch quotas. The closed areas can help protect, recover and maintain fish stocks, population size distribution, trophic complexity, ecosystem resilience, habitat structure, biological diversity as well as species feeding, breeding, spawning and nursery grounds. For management through deep-sea closed areas, there will be a need for science-based criteria and transparent processes for identifying areas appropriate for fishing as well as vulnerable marine ecosystems. Protection of vulnerable deep-sea living resources may require a combination of management tools which include complete ban on abandon of bottom trawls, using species and size selective gears like logline and traps.

The extent of sustainable exploitation of deep sea resources is doubtful, since the deep-sea ecosystem is much fragile when compared to the coastal zone. Exploitation of off-shore resources in the EEZ will have to be reconsidered in terms of not only the resources available, but also in terms of infrastructure. To avoid over-capitalisation and ensure a cautious growth of the infrastructure and investments, a rationalised approach will be essential in determining the number and size of fishing vessels, their resource specific gear as well as technology to be made available.

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