# PART 2: CURRENT PRACTICE CASE STUDIES

## FISHING CAPACITY AND EUROPEAN UNION FLEET ADJUSTMENT

**Erik Lindebo**[1]

**Abstract:** Fishing capacity in the European Union has historically been measured using aggregate tonnage and engine power of fishing vessels to allow the use of standardized measurements for all Member States. These measurements have formed the core of structural adjustment initiatives in the forms of the Multiannual Guidance Programmes (MAGPs) since 1983. These initiatives have been extended to incorporate measurements of fishing effort since 1992, forming the basis for Member States fleet capacity targets, traditionally based on biological advice.

In this paper, the framework, objectives and results of the MAGPs are considered. Vessel decommissioning schemes and other measures of Member States are examined with special attention given to the current MAGP initiative. Problems concerning the current use of fishing capacity measurements as criteria for the programmes are addressed, together with a discussion of the continued application of MAGP measures as a means to reduce the overexploitation of fish stocks and to improve fleet efficiency. The issue surrounding the expenditure of EU fleet adjustment is annexed.

## 1. INTRODUCTION

Many fisheries in the European Union (EU) are considered to be overcapitalized and require structural adjustment to encourage the rational and efficient exploitation of available resources. Fisheries management of national fleets has often been sought through volume-driven input controls as opposed to market-driven output controls. This has often led to fleet overcapacity and ‘race to fish’ behaviour, with the potential utilization of fishing capacity exceeding the optimal capacity levels. The EU and Member States (MS) have thus been required to pursue a structural policy in order to address the imbalance between fleet capacity and available resources.

This paper considers the concepts of fishing capacity and target capacity and examines these concepts as understood under the structural policy of Multiannual Guidance Programmes (MAGPs). The framework and results of these programmes are considered and the application is critically discussed in light of the defined objectives.[2].

## 2. FISHING CAPACITY

### 2.1 Definition

Fishing capacity is generally defined as "*the ability of a stock of inputs (capital) to produce output (effort or catch). Fishing capacity is the ability of a vessel or a fleet to catch fish*" (FAO, 1998: p. 2). It follows that fishing capacity is "*the maximum amount of fish over a period of time that can be produced by a fishing fleet if fully utilized, given the biomass and age structure of the fish stock and the present state of the technology*". That is,

$$Y_c = Y\,(E_c\,, S) \tag{1}$$

[1] Fisheries Economics and Management Division, Danish Institute of Agricultural and Fisheries Economics (SJFI) E-mail: erik@sjfi.dk. The author is grateful for helpful comments by Jørgen Løkkegaard at SJFI and Lars Christensen Clink at the Danish Ministry of Agriculture, Food and Fisheries. Any shortcomings of the paper, however, remain the responsibility of the author.

[2] The theoretical discussion surrounding the fishing capacity and target fishing capacity concepts is based on work of an earlier SJFI working paper prepared by the author (See Lindebo, 1999).

where $Y_c$ is current yield or catch, $E_c$ is the current effort generated by a fully utilized fleet (100 percent capacity utilization), $S$ is fish stock biomass, the fishing fleet is the stock of inputs, and assuming that management objectives are related to sustainability of the resource (FAO, 1998).

Although fishing is an economic activity, and fishing operations heavily depend on the economic outcome, the defining and measuring of fishing capacity in practice have excluded economic factors. Instead, fishing capacity has historically been estimated through the measurement of certain, relatively straightforward, physical characteristics of a fleet in order to give an indication of the maximum potential output. These characteristics may include the number of vessels, vessel tonnage, engine power, hold size, vessel length and gear and fishing methods used. Other determining factors, that may be more difficult to define, include available fishing time, stock catchability and skill and knowledge of the skipper and crew (technical efficiency).

The exact fishing capacity indicator used will depend on the characteristics of the fishery or fleet and the availability of reliable data. For example, it is generally accepted that for trawlers the single most important factor is engine power. For gill-netters, however, the engine effect would be of limited importance – it is more likely that vessel tonnage will determine fishing capacity, since the size of the vessel will largely determine the amount of gear and size of crew onboard. Applying a universal capacity measure across a range of fisheries may therefore prove inadequate and has proven to be a stumbling block when addressing the issue of global fishing capacity measurement. Applied measurement procedures may therefore only be applicable on a fishery-by-fishery basis, or at best, on a regional basis.

## 2.2 Measurement in the EU

Fishing capacity in the EU has historically been measured in terms of two vessel characteristics, namely gross tonnage of the vessel and engine power. These two characteristics have been monitored and registered as indicators of fishing capacity in the majority of MS. The number of vessels, number of fishers, and catch and landing data have also been monitored but have not been incorporated as official indicators in capacity reduction initiatives.

The number of kilowatts (total of the maximum continuous power)[3] of a vessel engine is a relatively straightforward measure, although differing measurement procedures in MS have caused some complications. Problems have included de-rating practices as well as differing measurements in terms of official kW and maximum effect kW.

The gross tonnage measure of the vessel has been less straightforward. Historically, tonnage has been measured as Gross Registered Tonnage (GRT), as defined by the Oslo Convention 1947, or as a particular national unit of tonnage. The EU has been progressively moving to a common standard for measuring tonnage, a volumetric measure known as Gross Tonnage (GT) as defined by the International Convention on Tonnage Measurement of Ships 1969. However, the tonnage registration of many MS fleets still includes a mixture of measurements as a result of the slow and complicated conversion procedure. Since the GT

[3] In accordance with Council Regulation (EEC) No 2930/86 of 22 September 1986 defining characteristics for fishing vessels (OJ L 274, 25/09/1986: p. 1-2).

measure often gives a higher tonnage value than the GRT measure, the total tonnage of the fishing fleet is also expected to increase accordingly.

Although both GT and GRT measure vessel volume, no meaningful conversion factor has been given to aid the tonnage standardization process. According to present legislation[4] all existing vessels with a length of 24 metres or more must now be measured in GT, as defined by Annex I to the 1969 Convention. All new vessels with a length of 15 metres or more must also be measured in GT in the same manner. Vessels of less than 24 metres, which have not been rebuilt or modified, may still be recorded in terms of GRT. These vessels, however, are required to be re-measured by 2004, according to the 1969 Convention.

A simpler method is allocated to new and existing vessels of less than 15 metres in length, due to the lesser importance of the superstructure volume of these vessels.[5]

$$GT = \left[0.2 + 0.02 log_{10}(V)\right] * V \tag{2}$$

where $V$ is volume, given by:

$$V = Loa * B_1 * T_1 \tag{3}$$

where *Loa* is the length overall (i.e. the distance between the forward and the after perpendiculars as defined by the International Convention for the Safety of Fishing Vessels); $B_1$ is the breadth in metres (according to the 1969 Convention); and $T_1$ is the depth in metres (according to the 1969 Convention).

Existing vessels with an overall length equal to, or greater than, 15 metres and less than 24 metres may be estimated in a similar manner in circumstances where the Commission considers the estimated values to be sufficiently accurate. This lenience has been temporarily granted due to the considerable technical demands involved in measuring vessels in accordance with the 1969 Convention.

In addition to this fishing capacity terminology, fishing capacity (as described above) has been used in the EU to define a further term of fishing effort, with the two terms working in parallel to achieve desired fleet reductions since 1992. Lassen *et al.* (1996) state that fishing effort can be considered as composed of two separate elements: a capacity element (vessel and gear characteristics) and an activity element (capacity utilization, fishing time etc.). That is,

$$Fishing\ Effort = Capacity\ \ (vessels) * Capacity\ \ (gear) * Activity \tag{4}$$

The EU adopted a fishing effort measure in individual fleet segments, in terms of aggregate tonnage, engine power and fishing activity. These are:

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[4] Council Regulation (EC) No 3259/94 of 22 December 1994 amending Regulation (EEC) No 2930/86 defining the characteristics of fishing vessels (OJ L 339, 29/12/1994: p. 11-13).

[5] In accordance with Council Regulation (EC) No 3259/94 of 22 December 1994 amending Regulation (EEC) No 2930/86 defining the characteristics of fishing vessels (OJ L 339, 29/12/1994: p. 11-13).

$$\textit{Fishing Effort (tonnage)} = \sum_{i=1}^{n} a_i J_i \tag{5}$$

$$\textit{Fishing Effort (engine power)} = \sum_{i=1}^{n} a_i P_i \tag{6}$$

where $n$ is the number of vessels in the fleet segment, $a_i$ is the vessel's number of sea-days during the observation period, $J_i$ and $P_i$ is the vessel's average tonnage (GT/GRT) and engine power (kW) respectively, in each fleet segment during the observation period.

The problem with the fishing capacity and fishing effort terminology is uncertainty surrounding the extent of any biological impact as a result of a reduction in fishing effort. Furthermore, the estimation of fishing effort is complex and objectives hence may be manipulated. Some Member States have adopted alternative measures for the purposes of capacity management (e.g. see Box 1 for the United Kingdom system).

**Box 1. Vessel Capacity Units**

In order to aggregate fishing capacity measurements of the fishing fleet, United Kingdom fisheries management has adopted Vessel Capacity Units (VCUs) as opposed to simply using units of tonnage and engine power. The unit uses a weighting procedure to derive an overall aggregate of fishing capacity:

$$VCU = Loa * B + (0.45 * P) \tag{7}$$

where $Loa$ is overall vessel length in metres, $B$ is vessel breadth in metres and $P$ is engine power of the vessel in kilowatts.

This unit is believed to be proportional to the vessel's ability to catch fish. The VCU measure serves as a backbone of a competitive tendering scheme under the decommissioning programme. Since the decommissioning scheme forms a vital component of management efforts to reduce overcapacity in United Kingdom fisheries, the use of a reliable and meaningful measure of capacity is of fundamental importance. The use of VCUs in the United Kingdom is not part of any EU regulation and remains a national, and somewhat controversial, initiative to deal with fishing capacity.

The current situation of MS fleets is monitored using monthly declarations to the Community register of fishing vessels. The register is meant to be a record of the physical characteristics of all the commercial marine fishing vessels in the EU fleet. In practice, however, the data for some nations are incomplete. In their monthly declarations, each MS must notify the Commission of any changes to the fleet, such as new constructions, withdrawals, modifications or changes in activity. The register is continually being updated and the reliability of the information improved. An amendment to the regulation was recently adopted which both extends and simplifies the information to be communicated, and also puts into place the procedures for direct access to the database by the MS. This will greatly speed up the exchange of information and allow the register to be used to monitor the access of vessels to the various fisheries.

# 3. TARGET FISHING CAPACITY

## 3.1 Definition

Overcapacity is evident in many global fisheries today. Biologically, overcapacity can be thought of as a level of capacity that, when fully utilized, produces a level of fishing mortality that threaten to reduce the fish stock biomass below the maximum sustainable yield (MSY). From an economic perspective, overcapacity can be defined as a fully utilized fishing capacity that reduces yield below the maximum economic yield (MEY) (Porter, 1998).

The extent of overcapacity can be estimated by accounting for the difference between the current potential capacity of the fleet and that of a defined optimal fleet capacity. A level of optimal capacity will differ from fishery to fishery and will also differ, since perceptions by biologists, economists, fisheries managers, politicians, etc., obviously vary. For example, the optimal level may be one that maximizes firm profits, maximizes supply to markets, maximizes regional employment or promotes fish stock growth. The optimal level of capacity is often perceived to be a capacity target level of fisheries management, with its estimation thus being highly dependent on fisheries specificity and management objectives. Holland and Sutinen (1998) state that regardless of which optimal or target level is chosen, and on what basis, the levels and the mix of variable inputs are expected to change as biological, economic and regulatory conditions change in the fishery. Hence, despite an unaltered fleet size, the potential, optimal and target capacity levels of the fleet may alter considerably.

FAO (1998: p. 11) have proposed a generic definition, where target capacity is *"the maximum amount of fish over a period of time that can be produced by a fishing fleet if fully utilized, while satisfying fishery management objectives designed to ensure sustainable fisheries"*. That is,

$$Y_T = Y\,(E_T\,, S) \tag{8}$$

where $Y_T$ is target yield or catch, $E_T$ is target effort generated by a fully utilized fleet, and $S$ is the fish stock size.

## 3.2 Measurement in the EU

The target level of fishing capacity of the EU fleet has historically been based on scientific advice from biologists, where the primary objective has been to balance fishing capacity with fish stock availability. Management targets have thus been given on the basis of what levels of fishing mortality are sought. The relationship between fishing mortality, fishing effort and fishing capacity is known to be complex since several processes may interact during a fishing operation that ultimately decide where and when fishing effort is employed. The relationship between fishing effort and fishing mortality is usually expressed as:

$$F = qE \tag{9}$$

where $E$ is effort and $q$ is the catchability coefficient. However, as Lassen *et al*. (1996) point out, an appropriate definition for practical use has been difficult to attain due to the lack of evidence proving a relation between individual input factors and fishing mortality. The common lack of information on crucial activity parameters, in addition to basic vessel and gear characteristics, provides further difficulties.

Gulland *et al*. (1990) concluded that an average 40 percent reduction in fishing mortality was required to rebalance fishing capacity with available resources in the EU. This included the recommendation of a 30 percent reduction in fishing of demersal stocks, a 20 percent reduction for benthic stocks, but no change in fishing of pelagic stocks. However, the report provided no guidance on how fishing capacity and fishing mortality were to be equated and no reliable mathematical model by which this can be done seems to exist (Holden, 1994).

Structural adjustment programmes in the EU have nonetheless directly based target capacity estimations on target levels of fishing mortality and spawning stock biomass of individual fish stocks. Current reduction targets of individual fleet segments (classified in terms of gear, area and stocks fished) are based on depletion risk (DR); overfished (OF) or fully exploited (FE) classifications for each fish stock (see Appendix A). The current MAGP aims to reduce fishing effort by 30 percent where DR stocks are exploited and by 20 percent where OF stocks are exploited. There should be no increase in fishing effort where FE stocks and other stocks are being exploited.

Each MS fleet segment or fishery has an effort reduction target (*ERT*) calculated in accordance with the following formula:

$$ERT = RR * W \tag{10}$$

where *RR* is the reduction rate and *W* is the percentage of the catch of a fleet segment or fishery that comprises depletion risk and overfished stocks. The reduction rate for a fleet segment or fishery is determined in accordance with the stock classification in Appendix A, by reference to the composition of its catch as between depletion risk, overfished, fully exploited or other stocks[6] (see Table 1).

*Table 1. Target fishing effort reductions for EU fleet segments and fisheries*

| DR stocks | OF stocks | FE stocks | Other stocks | % reduction |
|---|---|---|---|---|
| ✓ | x | ✓ or x | ✓ or x | 30 |
| x | ✓ | ✓ or x | ✓ or x | 20 |
| ✓ | ✓ | ✓ or x | ✓ or x | 25* |
| x | x | ✓ | ✓ or x | 0 |

Note: *if DR stocks amount to >5% of fleet segment/fishery catches then required reduction is 30% ✓ = included in fleet segment/fishery catch, x = not included in fleet segment/fishery catch. Source: Council Decision 97/412/EC.

The ultimate management advice has been very abstract in relation to the targets that have been set, despite being based on scientific advice. In addition, the advice that has been given has not always been followed. The targets that have been set have also only concerned the desired percentage change in capacity or effort over a set period of time and not the reaching of an ultimate target level. The targets for MS have been ultimately based on the situation of the fleet in 1983 (when the EU structural policy was first implemented) and have not based on any scientific estimations of overcapacity. Likewise, later EU entrants such as

[6] Council Decision 97/413/EC concerning the objectives and detailed rules for restructuring the Community fisheries sector for the period from 1 January 1997 to 31 December 2001 with a view to achieving a balance on a sustainable basis between resources and their exploitation (OJ No L 175, 3.7.97).

Spain and Portugal had fleet reduction targets set in accordance with their fleet situation at the time of their accession in 1986.

## 4. STRUCTURAL ADJUSTMENT OF THE FISHING FLEET

### 4.1 Framework

In order to attain a sustainable balance between the capacity of the EU fishing fleet and the available resources, and to reduce inefficient 'race to fish' behaviour, a comprehensive structural policy has been in force since 1983. This policy has been sought through a string of structural adjustment measures, including vessel decommissioning and effort reduction. Other measures such as joint ventures, export to third countries and various social support have also been applied but are not discussed in this paper. The measures have been implemented under the Multiannual Guidance Programme (MAGP) framework. The present programme, MAGP IV, runs until the end of 2001. Additional financing measures to renew and modernize vessels have also been applied to help restructure the EU fishing fleet, although applied separately to the MAGPs.

The probable impact of such structural adjustment on areas dependent on fishing can be measured both socially and economically. At a social level, a reduction in fishing capacity will have a negative effect on jobs at sea and the upstream sector (supplies, shipyards and harbour administrations). On the other hand, the downstream sector is likely to suffer only during the time required for the 'recapitalization' of fish stocks, since the quantities caught will eventually increase, thus increasing the number of jobs downstream. In economic terms, the profitability of fishing companies and competitiveness of European products is likely to improve as a result of the elimination of the overcapacity of the EU fleet. However, the negative effects of direct and indirect job losses will also need to be taken into account.

### 4.2 Vessel decommissioning

The principal objective of decommissioning is to reduce capacity, through the voluntary removal of redundant vessels, so as to bring fleets fishing particular resources into balance with their allocated quota. The process works by giving fishers a financial incentive to leave the fishery, usually in the form of a grant. In theory, the vessels that remain in the fishery will benefit and improve the overall efficiency as global production increases. The expected effects will include a significant improvement in the economic results of the fisheries companies, through a reduction in fixed costs and improved catches, and greater competitiveness (European Commission, 1996).

A successful decommissioning programme will rely on whether fishers can be drawn out of the fishery for future financial gain, as opposed to what they would otherwise gain if they remained in the fishery (Frost *et al*., 1995). Fishers may also withdraw from the fishery because of the poor future prospects regardless, resulting in a financial loss and reemployment elsewhere.

A vessel decommissioning programme is expected to remove the marginal players first (i.e. often the oldest and least efficient vessels) and it may prove more difficult to table sufficient financial incentives at the later stages of the programme in order to entice the more efficient vessels. It could also be expected that vessel decommissioning may lead to some redistribution of wealth, as the vessels left in the fishery may be able to exploit a larger share of the quota.

The programmes have been applied in most MS under the MAGPs. The issues of funding, eligibility and removal mechanism have often been addressed and defined by the individual MS management regime. For example, the United Kingdom programme has included the annual tendering of the permanent removal of VCUs of active vessels over 10 metres (Banks, 1998).

## 4.3 Effort reduction

A less permanent measure has been applied to MAGPs since 1992 under the fishing effort concept, where MS may reduce the overexploiting nature of fishing fleets by limiting their fishing activity (as described in Section 2.2). Generally knows as 'tie-ups', this measure requires vessels to remain in port for a minimum number of days in port per year, thus reducing the overall fishing effort and subsequent pressure on fish stocks. Although this measure may address the biological objectives it is unlikely to address the more fundamental issue of improving the structure of the fleets. Since this measure is largely a 'regulation by inefficiency', the overall economic situation of the fleet is unlikely to improve significantly, although employment levels may be maintained.

## 4.4 Vessel renewal and modernization

Grant aid has been allocated for the construction and modernization of fishing vessels to ensure that the EU fleet remains competitive, to improve safety on board vessels, to improve the quality of fish handling and to encourage the use of more selective gears. However, attaining aid is currently possible only if the corresponding increase in fishing effort has been allowed within the framework of the MAGPs. Close monitoring is required to ensure that the replacement of old and less efficient vessels with new or modernized vessels do not lead to an overall increase in effort that will hamper MAGPs reaching their objectives.

## 5. MAGP I AND II (1983-91)

MAGP I (1983-86)[7] was based on national programmes that were adopted in the form of a Commission decision that translated the institution's commitments with regard to the proposals made by each MS into its sectoral development plans. They determined the stabilization of fleet capacities for each MS by the end of 1986, simply expressed in power (kW) and tonnage (GRT). The goals were modest, but for the first time gave statutory expression of the desire to control the race for power. At the time, however, the fleet capacity in all MS exceeded the targets as there was a continued expansion in many fisheries, and the reasons for this were identified as (Gulland *et al.,* 1990):

- inconsistency in methods for measurement of capacity;
- absence of annual targets;
- lack of experience in structural policy; and
- absence of objectives for permanent withdrawal of existing vessels to compensate for new constructions.

[7] Council Regulation (EEC) No 2908/83 on a common measure for restructuring, modernising and developing the fishing industry and for developing aquaculture (OJ No L 290, 22.12.83).

MAGP II (1987-91)[8] was adopted within a new legal framework without undermining the planning principles of the previous regulation. The decisions taken by the Commission led to five-yearly requirements relating to a reduction in each nation's fleet capacity, by two percent in terms of power and three percent in terms of tonnage. With regard to fishing fleets, the MAGPs had to compromise a set of objectives, together with a statement of the means necessary for attaining them.

The minimum information to be contained in the MAGPs included:

- the initial situation and fishing capacity of the fleet, by category of vessel, type of fishing and region;
- the situation of the fleet and envisaged fishing capacity on completion of the programme; and
- the investments needed, the financial resources available and the legal and administrative provisions planned in order to attain the objectives.

Once again, however, MS race for power continued unchecked. This was largely due to massive state aids towards construction and technological improvement. Spain and Portugal joined the EU, practically doubling the size of the EU fleet, and increased the perceived competition within the EU fleet.

The system had no facility for controlling fleet entries and exits, other than through the application of a provision, namely Article 8 of Regulation (EEC) No 4028/86, which gave priority to construction aids to ship-owners who eliminated tonnage equivalent to that built. Being merely a priority rather than a requirement, this provision was generally disregarded. Under the same Regulation, the Community register of fishing vessels was established (see Section 2.2).

The relative failure of these programmes were attributed to (DGXIV, 1995):

- fishers and national authorities were not convinced that there was an overfishing problem;
- the relative ambiguity of the objectives and a lack of sufficient political thrust;
- continued aids towards the development of the entire fisheries sector;
- the nature of the tools for measuring the progress of the programmes and their results. The Community register of fishing vessels was not yet instituted and disparate units of fishing capacity, in terms of tonnage and engine power, complicated monitoring further; and
- the lack of proper monitoring of fleet entries and exits, resulting in major wastage of public funds. In effect, there was nothing to prevent decommissioned vessels being replaced by newly constructed vessels of the same capacity.

## 6. MAGP III (1992-96)

### 6.1 Objectives

The Commission drafted a rough proposal for a new MAGP that took account of the general state of the various stocks, as concluded by Gulland *et al*. (1990), and produced a range of desirable reductions over a five-year period. These included a 30 percent reduction in

[8] Council Regulation (EEC) No 4028/86 on Community measures to improve and adapt structures in the fisheries and aquaculture sector (OJ No L 376, 31.12.86).

fishing of demersal stocks, a 20 percent reduction for benthic stocks, but no change in fishing of pelagic stocks. It aimed to ensure that stocks in most danger of overfishing were correctly targeted under the fleet reduction programmes.

The proposals were met with a chilly response from MS, owing to its short-term economic and social implications. The Commission, therefore, decided on a one-year transitional programme for 1992, a two percent uniform reduction in fishing effort, to give extra time for continued negotiations. The MAGP was subsequently amended for the period 1993-96 and set the reduction levels of 20 percent for demersal stocks, 15 percent for benthic stocks and 0 percent for pelagic stocks.[9]

## 6.2 Fishing effort reduction

In contrast to the previous MAGPs, desired cuts were not expressed in terms of capacity reductions but of decrease in fishing effort (see Section 2.2). It was defined as the product of its capacity expressed in tonnage (GT) and installed power (kW) and the number of days spent at sea per reference period (t). MS also accepted the need for a common set of vessel measurements and agreed on the creation of a Community register of fishing vessels to make the information on fishing capacity and effort more open and easy to check.

Under the programmes, reductions could either be carried out through capacity reduction (vessel decommissioning) or by keeping vessels in port for set periods of time (effort control). At least 55 percent of the reduction had to be achieved by capacity reductions. Despite the adoption of this new target terminology, MS decided to reach their set objectives solely through capacity reductions. Some MS did attempt to utilize a reduction in effort to meet their objectives, but large uncertainties surrounding their implementation meant that the effort reduction approach was not used.

It was empirically estimated that over relatively long periods, technical progress was responsible for a constant, average increase in fishing effort of around two percent per year. It was, therefore, further decided that a corresponding and equally constant, average decrease in fishing effort was required. Technical progress could therefore turn fishing into a threat to the resource that needed to be offset by a corresponding adjustment in fishing effort.

## 6.3 Fleet segmentation

MAGP III set different targets for reducing fishing effort according to the type of stock being exploited (i.e. demersal, benthic or pelagic). The translation of these targets into concrete terms prompted each MS to segment its fleet depending on how each of its segments was geared towards these stocks, defined on the basis of the zone fished, the species exploited and the fishing gear used. The objectives for 1996 for each segment were calculated by applying the varying segment reduction rates, with the global objectives for 1996 and annual intermediate objectives calculated as the sum of the objectives by segment.

Special provisions were made for multipurpose vessels that alternately targeted sensitive and non-sensitive stocks to which different guideline rates for reducing fishing effort applied. In such cases, the use of measures to reduce effort targeted at sensitive stocks were advocated in order to avoid reducing the capacities of a segment whose fishing pressure on

[9] Council Regulation (EEC) No 3760/92 establishing a Community system for fisheries and aquaculture (OJ No L 389, 31.12.92), amended by Council Regulation (EC) No 1181/98 (OJ No L 164, 9.6.98).

non-sensitive stocks was not excessive. In areas where indiscriminate fishing activities made it impossible to identify a single-species fishery, the guideline rate for the most sensitive species in the area was applied.

The procedure to segment MS fleets, however, only allowed MS to make the programme objectives more unclear and caused further confusion over the relationship between the set objectives and the biological advice that it was based upon.

## 7. FLEET DEVELOPMENT

Fleet capacities continued to grow until 1986/87, after which it stabilized between 1986/87 and 1992. Although no reliable documentation of fleet expansion exist, the expenditure towards construction and modernization, in relation to capacity reduction (see Appendix C), indicates that the EU fleet capacity would have increased during the 1983-90 period. However, MAGP III began to make real inroads into capacity with the implementation of the transitional MAGP for 1992.

Reduction in fleet capacity accelerated with an 18 percent reduction in tonnage and a 12 percent reduction in power of the EU fleet during the 1991-96 period (Table 2).

*Table 2. Developments in the size of the EU fleets against MAGP targets*

| End of year | Tonnage (GRT) | | Power (kW) | |
|---|---|---|---|---|
| | Objectives | Situation fleet register | Objectives | Situation fleet register |
| 1991 | 2 044 511 | 2 010 183 | 8 290 422 | 8 347 453 |
| 1992 | 2 003 621 | 1 934 811 | 8 124 614 | 8 188 936 |
| 1993 | 1 977 951 | 1 843 750 | 8 020 807 | 7 963 704 |
| 1994 | 1 936 824 | 1 777 083 | 7 896 177 | 7 778 111 |
| 1995 | 1 895 696 | 1 710 673 | 7 771 547 | 7 555 011 |
| 1996 | 1 859 028 | 1 644 113 | 7 691 700 | 7 328 117 |
| % change | 1991 to 1996 -18% | | 1991 to 1996 -12% | |

Note: excluding Finland and Sweden. Source: European Commission (1997).

However, the progress towards meeting the 1996 targets was very uneven, despite the fact that for the EU as a whole the overall targets had been clearly met by the end of 1996. The situation of the Dutch and United Kingdom fleets were of particular concern. As seen in Table 3, these two nations were still required to make cuts in both tonnage and engine power at the end of 1996. By contrast, a number of MS had more than met their targets, thereby allowing them access to EU grants for vessel renewal and modernization.

A further problem was that although the overall required reduction targets had been met, this masked a number of points of detail regarding progress in each MS. Each MS had to reach the individual targets set for each fleet segment and some MS that had already achieved their overall targets still had to make further reductions in particular fleet segments. For example, the United Kingdom had already met its 1996 targets for a number of segments by the end of 1994, but it still had about 18 percent and 36 percent overcapacity respectively in key demersal trawler and beam trawler segments.

*Table 3. MS fleet objectives and situations 1996*

| Member State | Tonnage (GRT) Sit./Obj. 1996 | Tonnage (GRT) Segments reaching Objective 1996 | Power (kW) Sit./Obj. 1996 | Power (kW) Segments reaching Objective 1996 |
|---|---|---|---|---|
| Belgium | -4% | 1/2 | -6% | 1/2 |
| Denmark | -23% | 5/5 | -19% | 5/5 |
| Finland | -4% | 6/6 | -2% | 5/6 |
| France | -1% | 4/6 | 4% | 2/6 |
| Germany | -21% | 8/9 | -13% | 9/9 |
| Greece | -4% | 2/3 | 0% | 2/3 |
| Ireland | -6% | 2/3 | -1% | 2/3 |
| Italy* | -2% | n.a. | 4% | n.a. |
| Netherlands | 48% | 0/3 | 9% | 0/3 |
| Portugal | -36% | 9/9 | -24% | 9/9 |
| Spain | -24% | 5/5 | -15% | 5/5 |
| Sweden | -3% | 3/5 | -3% | 5/5 |
| United Kingdom | 4% | 4/10 | 2% | 6/10 |
| EU total | -12% | 49/66 | -5% | 51/66 |

* based on Italy report. Source: European Commission (1997).

## 8. CURRENT MAGP IV (1997-2001)

### 8.1 Objectives

At the end of the period of application of the MAGP III, it was clear that while there had been some decline in the surplus capacity of the EU fleet, all the objectives had not been achieved, in particular by certain MS. Numerous issues arose following the end of MAGP III (des Clers, 1996). Firstly, fleet reduction was globally fixed and concerned only overexploited demersal (20 percent) and benthic (15 percent) stocks, probably encouraging capacity build-up in the less regulated pelagic, semi-pelagic and shellfish fisheries, and on stocks straddling on the high seas. Secondly, continued contradictory policies and lack of socio-economic underpinning failed to give priority to the decommissioning of the fleet actually targeting overexploited stocks.

Moreover, the technical progress achieved in the industry over the period certainly hampered compliance with the guidelines. A further factor was the repetition of catastrophic declines in fish prices, which led some fleets to increase fishing to offset the drop in income. This contributed to increasing fishing effort, further aggravating overexploitation of resources. The fleet restructuring measures, therefore, had thus far been unable to improve stocks or boost competitiveness and efficiency. It appears that the status of the majority of stocks had not significantly changed over the period.

Before MAGP IV was implemented, the Commission asked a group of independent experts to evaluate the state of fish stocks (Lassen *et al.,* 1994). This report showed that several commercial stocks were still coming under far too much fishing pressure. As a result, the Council decided that fishing effort under MAGP IV should be cut by 30 percent where stocks were in danger of collapse (depletion risk) and 20 percent where stocks were being overfished, with a zero increase in fishing effort for other stocks (see Appendix A). The rates were regarded to be moderate according to the percentage of the catch made up of these stocks. Vessels of less than 12 metres overall length that used passive gears were exempt from any reduction requirements.[10] Backlogs stemming from the previous programme were also

[10] Council Decision 97/413/EC.

incorporated into the new programme. The current EU and MS fleet objectives for MAGP IV are given in Table 4 and 5.

*Table 4. EU fleet objectives for 2001*

| End of year | Tonnage (GT) | | Power (kW) | |
|---|---|---|---|---|
| | Objectives | Situation fleet register | Objectives | Situation fleet register |
| 1996 | 2 114 810 | 1 774 685 | 6 820 931 | 6 321 292 |
| 1997 | | 1 726 319 | | 6 146 604 |
| 2001 | 2 065 707 | | 6 618 026 | |

Note: Excluding Italy. Source: European Commission (1999).

*Table 5. Member State fleet objectives for 2001*

| Member State | Tonnage (GT) | | | Power (kW) | | |
|---|---|---|---|---|---|---|
| | Situation 1997 | Objective 2001 | Sit.1997/ Obj. 2001 | Situation 1997 | Objective 2001 | Sit. 1997/ Obj. 2001 |
| Belgium | 23 099 | 23 323 | -1% | 64 896 | 67 857 | -4% |
| Denmark | 98 411 | 132 539 | -26% | 380 809 | 463 437 | -18% |
| Finland | 24 197 | 22 992 | 5% | 220 066 | 212 847 | 3% |
| France | 191 744 | 185 686 | 3% | 959 614 | 922 357 | 4% |
| Germany | 68 781 | 81 973 | -16% | 161 706 | 170 050 | -5% |
| Greece | 110 362 | 120 755 | -9% | 655 752 | 654 172 | 0% |
| Ireland | 58 603 | 69 649 | -16% | 179 744 | 199 009 | -10% |
| Netherlands | 146 581 | 131 809 | 11% | 399 891 | 347 095 | 15% |
| Portugal | 121 539 | 195 885 | -38% | 394 684 | 497 246 | -21% |
| Spain | 587 172 | 799 253 | -27% | 1 468 300 | 1 755 636 | -16% |
| Sweden | 48 181 | 51 159 | -6% | 245 749 | 261 857 | -6% |
| United Kingdom | 247 649 | 250 684 | -1% | 1 015 393 | 1 066 463 | -5% |
| EU total | 1 726 319 | 2 065 707 | -16% | 6 146 604 | 6 618 026 | -7% |

Note: Excluding Italy. Source: European Commission (1999).

The programme concentrates the reductions in effort on those fleet segments operating on the most vulnerable stocks and attempts to minimize their short-term socio-economic impact. In order to reach the objectives each MS must adopt legislation to control the renewal of the fleet, which on a segment basis determines the required ratio between entries and exits of vessels. It follows that aid cannot be granted to the renewal and modernization of the fleet, resulting in an increase in fishing effort, unless stated objectives have been met (see Appendix C). Since the overall objectives of MAGP IV have already been met (see Table 4), it should be anticipated that the capacity of the EU fleet will increase through renewal and modernization in eligible fleet segments.

A problem that should be considered is that the concentration of the programmes on stock vulnerability criteria has purely been a technical issue. That is, there is no apparent relationship between the calculated reductions and the fishing pressure on these stocks, and the catch data that is used is not public information.

## 8.2 Fishing effort reduction

The programme fixes the effort reduction objectives to be achieved for defined MS fleet segments, according to the stocks exploited and the fishing gear employed (see Section 3.2). Annual intermediate targets continue to be in force. For vessels using active gears, effort reduction can be achieved by either reduction in capacity or effort, or a mixture of the two, providing that effort can be effectively monitored and controlled. Germany, France, Ireland, the Netherlands, the United Kingdom and Sweden make use of this provision in some fleet segments, whereas other MS intend to achieve their objectives purely through reductions in capacity. Because of this, the required overall capacity reductions have been lessened due to some MS fleet segments seeking reductions through effort control. MS can still decide on the manner they intend to meet their objectives and targets have been calculated, taking possible backlogs of the previous MAGP into account (see Danish example in Appendix B).

Considerable problems with fishing effort reduction, as outlined above, include that the determination of reference levels and fleet segmentation has not been undertaken in an objective manner. The element that accounts for backlogs of the previous programme has been particularly subject to subjective decisions and has in many cases resulted in lenient target amendments.

## 9. MAGP V - AIMS AND OBJECTIVES

A mid-term review of MAGP IV is currently under way and a recent report by the Scientific, Technical and Economic Committee for Fisheries (STECF, 1999) can be seen as a preliminary contribution to the overall review. STECF recognizes in their report to the Commission that in order to prepare for the next MAGP phase, a full evaluation of previous programmes needs to be undertaken.

This needs to consider the following:

- the implementation of programmes;
- effects on stocks and fisheries;
- assess whether objectives have been met;
- assess the extent of anticipated and unanticipated side effects.

The STECF (1999: p. 11) further considers that: *"In view of the low reduction rates applied to Member States' fleets in MAGP III and IV in comparison to what was recommended according to the state of the stocks, and the way they have been applied, the primary objective of matching fishing capacity to resource availability is unlikely to have been fully achieved by the end of 2001"*.

A comprehensive evaluation should therefore address the implementation process (e.g. segmentation, scrap and build policies, activity changes etc.) and how economic and other incentives have influenced their effectiveness. STECF (1999) further suggests that for the Commission to implement MAGP V successfully, the following areas will need to be investigated or clarified:

- review the state of the fish stocks exploited by the European fleets, including those found in third country waters;
- review the economic situation of the fleets;
- comment on the levels of fishing mortality in relation to precautionary fishing mortality reference points (or similar reference points);
- gain a better understanding of fleet dynamics and the behaviour of fleet segments in relation to specific management measures giving an insight to the likely effectiveness of such measures;
- further investigate the fishing capacity, fishing effort and fishing mortality relationship to anticipate more accurately the effects of capacity reductions on fishing mortality.

The latter issue is especially important since it is recognized that, in principle, the control of capacity and effort can be used to control the overall level of fishing mortality. It will therefore be important to define what is meant by each concept and how they will be measured, and to understand the practical relationship between these concepts.

It is anticipated that the main objective of MAGP V will continue to be the matching of EU fishing capacity to resource availability, through similar fleet adjustment initiatives.

## 10. DISCUSSION

The continued application of MAGPs in order to restructure EU fishing fleets raises a number of issues that need to be addressed. This includes the definition and measurement of fishing capacity, the use of vessel decommissioning and the application of effort restrictions. Any effective reductions in fishing capacity/effort may be offset by vessel renewal and modernization and the role of investment grants in the overall structural policy, therefore, also needs to be considered.

### 10.1 Fishing capacity/effort reduction

Fishing capacity has been measured in terms of vessel tonnage and engine power. Vessel tonnage has been registered as GRT, GT and other national units. The mixture of these measurements has caused some confusion in relation to MAGP objectives and situations of national fleet segments. Although it is anticipated that measurements will be harmonized, the results of previous MAGPs should be interpreted with some scepticism. Engine power, in terms of kW, has been a more straightforward unit to measure although technical problems such as de-rating practices may have underestimated the registered engine power of some vessels. Furthermore, engine power has been measured and registered as both official and maximum effect units and has hence led to further confusion over the exact development of fleet engine power. Measurement discrepancies have prompted frequent adjustment of figures in the Community register of fishing vessels and obvious problems can be viewed by referring to the exact values in the tables given in this paper.[11] The lack of reliable and harmonious capacity indicators should be seen as one of the main stumbling blocks in past and present capacity reduction initiatives.

If practical measurement problems are overcome there may still be more a theoretic complication that needs to be addressed. Defining fishing capacity in terms of two input units could be scrutinized. Fishing capacity, or the ability of a vessel to catch fish, is a highly complex concept and depends on multiple-inputs. Although tonnage and engine power will significantly affect the vessel's catching ability, and monitoring of these inputs may provide a simple indicator of capacity, it should be acknowledged that other inputs that are not monitored may allow an increase in effective fishing capacity (through input substitution). The levels of capacity utilization, technical efficiency and technical progress will also determine the ability of vessels to catch fish and need to be considered. The fishing capacity, fishing effort and fishing mortality relationship (that MAGP advice has been based upon) also needs to be further analyzed.

Capacity reduction through vessel decommissioning should also be debated. It is clear that the least efficient vessels are those that are likely to be removed from the fishery first. These vessels may, in effect, not have a considerable impact on overall catches and their removal may, therefore, not have a significant effect on fishing pressure. If relatively efficient

[11] See the Danish example in Appendix B where tonnage and engine power values differ in the official Danish MAGP report from those subsequently registered in the Community register of fishing vessels, as a result of using various measurement units.

vessels are removed, the remaining vessels may be allowed to increase their effort in order to utilise a larger share of the quota (‘effort creeping’), resulting in a similar level of pressure on stocks. Vessel decommissioning can also be expected to become more expensive with time as the more efficient vessels will require greater financial incentives to be enticed out of the fishery, and the required expenditure for such a scenario is virtually unknown.

The reduction in fishing effort allows MS to reduce their required cuts in physical fishing capacity. Although this may have a similar effect on fishing pressure on stocks, if compared to capacity reduction, it should be considered that restricting vessel activity is only a temporary solution and does not assist to structurally adjust the size of the fleet to available resources. This will maintain an artificially high level of fishing capacity, in excess of what is desired. However, a restriction on effort will probably reduce profits and may force some inefficient vessel out of the fishery.

### 10.2 Vessel renewal and modernisation

In order to encourage EU fleet efficiency, to improve safety on board vessels, to improve the quality of fish handling and to encourage the use of more selective gears, construction grants have been made available throughout the period of the MAGPs. It could be argued that an increase in capacity for safety purposes only serves for that purpose and may not necessarily mean that the vessel will fish more intensively. However, criticism has focused on the lack of co-ordination between the restructuring elements of vessel decommissioning and construction and the structural policy was hence considered as one of ‘scrap and build’ up until 1992, when the focus on reduction was eventually readdressed and clarified.

It has been recognized that the removal of old and relatively inefficient vessels through decommissioning was followed by the construction of new vessels that were more efficient at catching fish. Grants towards modernization of older vessels have also assisted to increase fishing pressure through technological improvement (e.g. a moderate estimate is a two-three percent productivity increase per year), in addition to the general upkeep of vessels that owners will invest in. Therefore, despite recognized capacity reductions in terms of tonnage and engine power during the latter MAGP period, the effective fishing capacity of the MS fleets may have remained unaltered or actually increased. This was particularly a problem during the 1980s where measures used to curb fishing capacity were largely made ineffective as a result. The 1990s have seen stricter controls on the granting of aid for renewal and modernization although it has continued to cause controversy. Future grant restrictions are currently being discussed (see Appendix C), where the discussion is fuelled by considerable national differences. The continued modernization of some MS fleets have also been seen as a competitive threat to other MS, leading to lobbying for the availability of further construction grants in certain MS.

### 10.3 The Commission’s role

In addition to the many theoretical and practical difficulties facing the implementation of a successful capacity reduction mechanism in the EU, the role of the Commission itself has limited its progress to some extent. The Commission has added to the lack of clarity of programmes by allowing MS to adjust programme objectives through accepting different capacity definitions and measurements. Furthermore, amendments of MS objectives have sometimes been adopted, as well as complex fleet segmentation procedures, seemingly aiding to mask the overall capacity situation of MS fleets. Without the clarity of programme elements and objectives it is a considerable task to assess whether there has in fact been any real reduction in fishing pressure on overexploited stocks.

## 11. CONCLUDING REMARKS

EU fisheries have been subject to transnational adjustment efforts in order to address the imbalance of fishing capacity and available resources. This has included the application of MAGPs where objectives have been set in terms of desired reductions in fishing capacity of the fleets, and more recently through the reduction of fishing effort of individual fleet segments targeting specific stocks, or through a combination of the two. Difficulties of trying to address biological imperatives while accommodating a multitude of political, economic and socio-economic interests have hampered its progress.

Due to the severe lack of reliable and transparent data, the exact monitoring of the progress of fleet development in relation to programme objectives has been difficult. Therefore, this paper has been unable to analyze empirical examples to any great extent that would have assisted a more comprehensive assessment of the capacity reduction initiatives.

Although most of the latter MAGP reduction objectives have been met, the translated effect of a similar reduction in fishing pressure on stocks remains in doubt. It can be expected that issues such as technological improvement, effort creeping following vessel decommissioning, grants for vessel renewal and modernization, temporary effort restrictions, lack of compliance by certain fleet segments, and possible relocation of capacity in less regulated fisheries, will all determine the success of the continued application of such programmes. The principal fishing capacity, fishing effort and fishing mortality relationship, including their definition and reliable measurement, will require further analysis if meaningful fleet reduction targets are to be set in accordance with the desired multi-objectives of EU fisheries management.

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## APPENDIX A. CLASSIFICATION OF STOCKS

*Table 6. Critical stocks as stated in Council Decision 97/413/EC, concerning the objectives and detailed rules for restructuring the Community fisheries sector for the period from 1 January 1997 to 31 December 2001 with a view to achieving a balance on a sustainable basis between resources and their exploitation.*

| Species | III bcd | III a | IV | VI | VIIa | VII bc | VII efg hjk | VII d | VIII abd | VIIIc IXa | MS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Herring (*Clupea harengus*) | | FE | DR | | | | FE | OF | | | |
| Mackerel (*Scomber scombrus*) | | DR | DR | OF | OF | OF | OF | OF | OF | OF | |
| Sardine (*Sardina pilchardus*) | | | | | | | | | | DR | |
| Salmon (*Salmo Salar*) | DR | | | | | | | | | | |
| Bluefin Tuna (*Thunnus thynnus*) | | | | | | | OF | OF | OF | OF | OF |
| Swordfish (*Xiphias gladius*) | | | | | | | OF | OF | OF | OF | OF |
| Cod (*Gadus morhua*) | OF | DR | DR | DR | DR | | OF | DR | | | |
| Haddock (*Melanogrammus aeglefinus)* | | OF | OF | OF | FE | | | OF | | | |
| Whiting (*Merlangus merlangius*) | | | FE | OF | FE | | FE | FE | | | |
| Saithe (*Pollachius virens*) | | OF | OF | DR | | | | | | | |
| Hake (*Merluccius merluccius*) | | OF | OF | OF | OF | OF | OF | OF | OF | DR | |
| Plaice (*Pleuronectes platessa*) | | OF | DR | | FE | | DR | FE | | | |
| Sole (*Solea* spp.) | | | DR | | OF | | DR | OF | OF | | |
| Anglerfish (*Lophius* spp.) | | | | OF | OF | OF | OF | OF | OF | OF | |
| Megrim (*Lepidorhombus* spp.) | | | | FE | FE | FE | FE | FE | FE | FE | |
| Nephrops (*Nephrops norvegicus*) | | OF | FE | FE | FE | | FE | | OF | FE | |

**DR** Depletion risk: Spawning stock biomass presently below Mbal or likely to be in that position in the short-term at current levels of fishing mortality.
**OF** Overfished: Moderate to substantial gains in long-term yield if effort is decreased; if heavily overfished, medium-term risk of spawning stock biomass falling below Mbal.
**FE** Fully exploited: No substantial long-term gains or losses if effort is moderately increased or reduced.

**Zones:** III bcd (Baltic Sea), IIIa (Skagerrak and Kattegat), IV (North Sea), VI (West Scotland), VIIa (Irish Sea), VIIbc (West Ireland), VIIefghjk (Celtic Sea and Western Channel), VIId (Eastern Channel), VIIIabd (Bay of Biscay), VIIIc and IXa (Iberian Peninsula), and MS (Mediterranean Sea).

## APPENDIX B. OBJECTIVES OF MAGP IV - DANISH EXAMPLE

*Table 7. Objectives and situations of Danish fleet segments at the end of 1997*

| Category | Code | | Objective end 1996 | Situation end 1996 | Situation end 1997 | Develop. 1997 | Objective end 2001 | Sit. 1997/ Obj. 2001 |
|---|---|---|---|---|---|---|---|---|
| Small-scale vessels | 4B1 | GT | 11 387 | 9 428 | 8 631 | -797 | 11 387 | -24% |
| | | kW | 92 429 | 82 991 | 77 856 | -5 135 | 92 429 | -16% |
| Netters | 4B2 | GT | 12 269 | 8 038 | 7 258 | -780 | 8 981 | -19% |
| | | kW | 50 142 | 36 729 | 33 081 | -3 648 | 36 704 | -10% |
| Trawlers/ | 4B3 | GT | 102 342 | 81 170 | 81 295 | 125 | 100 500 | -19% |
| seiners (Danish seine) | | kW | 317 822 | 276 143 | 269 282 | -6 861 | 312 101 | -14% |
| Purse seiners/ | 4B4 | GT | 12 045 | 7 863 | 8 237 | 374 | 11 672 | -29% |
| pelagic trawlers | | kW | 22 913 | 15 821 | 15 821 | 0 | 22 203 | -29% |
| Total | | GT | 138 043 | 106 499 | 105 421 | -1 078 | 132 539 | -20% |
| (Danish report) | | kW | 483 306 | 411 684 | 396 040 | -15 644 | 463 437 | -15% |
| Total | | GT | 138 043 | 97 629 | 98 411 | 782 | 132 539 | -26% |
| (EU register) | | kW | 483 306 | 392 526 | 380 809 | -11 717 | 463 437 | -18% |

*Table 8. Fishing effort situation of Danish fleet segments in 1997*

| Category | Code | | Fishing effort 1997 |
|---|---|---|---|
| Small-scale vessels | 4B1 | GT days | 526 732 |
| | | kW days | 4 348186 |
| Netters | 4B2 | GT days | 1 190 741 |
| | | kW days | 5 398 158 |
| Trawlers/ | 4B3 | GT days | 7 216 230 |
| seiners (Danish seine) | | kW days | 52 567 497 |
| Purse seiners/ | 4B4 | GT days | 1 511 366 |
| pelagic trawlers | | kW days | 2 904 805 |
| Total | | GT days | 10 445 069 |
| | | kW days | 65 218 646 |

Source: European Commission (1999).

*Table 9. Fishing effort reduction objectives of Danish fleet segments during MAGP IV*

| Area | Stocks | Segment | Catch composition | Pilot rate | Weighted reduction | Situation end 1997 | | Objective end 1997 | | Objective end 2001 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GT* | kW | GT* | kW | GT* | kW |
| Coastal waters | | Small-scale vessels < 12 m | | 0% | 0% | 9 428 | 82 991 | 11 387 | 92 429 | 11 387 | 92 429 |
| | | | | | Subtotal | 9 428 | 82 991 | 11 387 | 92 429 | 11 387 | 92 429 |
| EU waters | Demersal and Flatfish | Netters | DR: 72.3%<br>OF: 16.9%<br>Other: 10.8% | 30% | 26.8% | 8 038 | 36 729 | 12 269 | 50 142 | 8 981 | 36 704 |
| EU waters International waters | Demersal Flatfish, Pelagic and Crustacea | Trawlers/ seiners (Danish seine) | DR: 3.7%<br>OF: 3.5%<br>Other: 92.8% | 25% | 1.8% | 81 170 | 276 143 | 102 342 | 317 822 | 100 500 | 312,101 |
| EU waters International waters | Pelagic | Purse seiners/ pelagic trawlers | DR: 10.4%<br>OF: 0%<br>Other: 89.6% | 30% | 3.1% | 7 863 | 15 821 | 12 045 | 22 913 | 11 672 | 22 203 |
| | | | | | Subtotal | 97 071 | 328 693 | 126 656 | 390 877 | 121 152 | 371 008 |
| | | | | | Total | 106 499 | 411 684 | 138 043 | 483 306 | 132 539 | 463 437 |

Note: DR = depletion risk, OF = overfished
GT* includes estimated GT values in accordance with the present Decision. Objectives will be revised as real GT values become available.
Source: Commission Decision 98/126/EC.

## APPENDIX C. STRUCTURAL ADJUSTMENT EXPENDITURE

The provisions of the 1986 structural regulation were originally scheduled to run for ten years. In 1993, however, as part of a general reform of the Structural Funds, all the common structural measures relating to fisheries were integrated into the overall system of EU structural funding under a single financial instrument, the Financial Instrument for Fisheries Guidance (FIFG). The specific tasks of the FIFG included helping to achieve a sustainable balance between resources and their exploitation, a strengthening of the competitiveness of structures and the development of economically viable enterprises.

The regulation required each MS initially to draw up a single programming document, to include a sectoral plan for fisheries together with an aid application. The sectoral plan had to contain a strategy to the adjustment of fishing effort and the renewal and modernization of the fleet, as well as the means (legal, financial, etc.) envisaged for attaining those objectives. Other measures (e.g. supports to markets, aquaculture, port facilities, training etc.) were also included but are not the focus of this paper.

The total annual expenditure by the EU on aid for vessel construction and modernization projects, as well as on aid for adjustment of capacity, during the period 1983-93 is summarized in Table 10. It is apparent that during the period 1983-90 very large sums in EU aid were directed towards vessel construction projects. After 1990, however, when the rates of aid were reduced and the Commission adopted a stricter attitude to the granting of aids to those nations not meeting their MAGP targets, there was a significant reduction in this category of aid. At the same time, aid towards fleet reduction measures increased considerably.

*Table 10. Annual EU aid for fleet measures 1983-93 (ECU million)*

| | EEC 10 | | | EEC 12 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
| Construction | 21.3 | 39.1 | 46.8 | 38.7 | 64.0 | 8.7 | 63.5 | 44.2 | 7.8 | 5.0 | 4.0 |
| Modernisation | 7.0 | 10.4 | 15.2 | 18.0 | 9.2 | 19.3 | 20.3 | 26.2 | 21.4 | 14.7 | 19.1 |
| Reduction | 6.9 | 6.9 | 6.9 | 6.9 | 26.2 | 31.2 | 25.7 | 49.8 | 125 | 113 | 155.8 |
| Other | 0.0 | 0.0 | 2.3 | 3.9 | 1.9 | 16.8 | 14.6 | 13.0 | 32.3 | 77.4 | 62.3 |
| Total | 35.2 | 56.4 | 71.2 | 67.5 | 101.3 | 76.0 | 124.1 | 133.2 | 186.5 | 210.1 | 241.2 |

Source: Hatcher (1998).

The total budget allocations (EU and national) approved by the Commission for the fleet renewal measures (renewal and modernization projects) and effort adjustment measures under the sectoral plans submitted by each MS for the period 1994-99 is given in Table 11.

The FIFG regulation for 2000-2006 is due to be approved and includes the continued provision for a mechanism to manage fleet development, aiming to achieve an appreciable reduction in fleet capacity. This mechanism will be governed by certain principles, some of which are still under discussion (e.g. entry/exit ratio):

MS will have to establish a permanent programme of fleet additions and removals, wherein additions through the building of new units backed by public funds will be conditional on the withdrawal of greater capacity achieved without public aid. To obtain a grant to build 100 tonnes, investors will have to withdraw 130 tonnes without public aid. The MAGP IV annual targets as well as the targets for the relevant segment also have to be met.

Small-scale fishing fleets are exempt from this rule where additions must not lead to an overall increase in fishing effort

*Table 11. EU aid for fleet measures 1994-99 (ECU million)*

| MS | Adjustment of fishing effort | | | Construction and modernization | | | |
|---|---|---|---|---|---|---|---|
| | FIFG | Public | Total | FIFG | Public | Private | Total |
| Belgium | 5.20 | 5.20 | 10.40 | 7.88 | 3.94 | 27.58 | 39.40 |
| Denmark | 37.74 | 37.74 | 75.48 | 35.06 | 7.01 | 98.17 | 140.24 |
| Finland | 4.14 | 4.14 | 8.28 | 2.41 | 1.06 | 6.55 | 10.02 |
| France | 16.19 | 16.19 | 32.38 | 37.81 | 29.48 | 89.01 | 156.30 |
| Germany | 8.66 | 12.68 | 21.34 | 32.61 | 5.76 | 66.60 | 104.97 |
| Greece | 31.77 | 10.59 | 42.36 | 14.29 | 4.76 | 24.25 | 43.30 |
| Ireland | 5.56 | 1.86 | 7.42 | 11.70 | 1.91 | 24.58 | 38.19 |
| Italy | 104.58 | 104.58 | 209.16 | 93.22 | 23.10 | 115.11 | 231.43 |
| Netherlands | 9.50 | 9.50 | 19.00 | 2.20 | 0.88 | 13.90 | 16.98 |
| Portugal | 82.05 | 28.02 | 110.07 | 36.23 | 8.07 | 29.68 | 73.98 |
| Spain | 378.97 | 188.09 | 567.06 | 334.38 | 71.66 | 310.56 | 716.60 |
| Sweden | 4.00 | 4.00 | 8.00 | 12.00 | 4.00 | 24.00 | 40.00 |
| United Kingdom | 19.15 | 13.84 | 32.99 | 20.13 | 4.73 | 28.02 | 52.88 |
| EU total | 707.51 | 436.43 | 1 143.94 | 639.92 | 166.36 | 858.01 | 1 664.29 |

Note: Values for Finland and Sweden are for 1995-99. Source: European Union aid for the development of the fishing industry, DGXIV (1998).

Penalty measures against MS that do not observe the rules agreed in the MAGP and the Community register of fishing vessels will be strengthened. Thus, if the addition/removal programme is not put in place, or if it is not operational, public financial support for the renewal of the fleet will be forbidden and applications for third country licences may be suspended.

The three types of permanent cessation of fishing activities (scrapping, export to a third country or assignment to activities other than fishing) will continue.

# CRITICAL CONSTRAINTS TO REGULATE FISHING CAPACITY FOR SUSTAINABLE HARVESTS IN SOUTHEASTERN BRAZIL – NOTES FROM THE BRAZILIAN SARDINE FISHERY EXPERIENCE

**M.A. Gasalla and S.L.S. Tutui**[1]

**Abstract**: Over the last 20 years, the Brazilian sardine fishery has experienced a considerable increase in fishing effort and a corresponding decrease in stock abundance. While natural oceanographic events have contributed to the decline in stock size, overfishing is considered a major factor underlying the depletion of the stock. In this paper, the results of a survey of experts on factors that limit the development of effective fisheries management in Brazil are presented. The survey identifies a range of factors, ranging from structure of the bodies responsible for fisheries management, policies that are not based on scientific evidence and poor enforcement.

## 1. INTRODUCTION

The Brazilian sardine fishery is the main capture fishery of Southern Brazil in terms of fishing effort employed. Excessive effort, in combination with adverse oceanic conditions for spawning, resulted in the stock being overfished since the late 1980s. Natural variability, also related to oceanographic structure, affected recruitment success and larval survival, and hence is an important factor that explained the decline in the sardine stock. However, these variations did not reduce the importance of the regulation of fishing capacity.

In this paper, experiences from the Brazilian sardine fishery will be used to determine the critical constraints important for management that could promote sustainable harvests. To assess the constraints, the analysis followed two steps: (1) assessment of the problems reviewing historical data and official documents, and (2) identification of constraints by a survey of experts' based on questionnaires. The objectives of the survey were to: (a) identify the factors that a panel of experts believe have the greatest importance to the decision-making process when considering regulation of fishing capacity in the region, and (b) highlight the relative importance of main considered factors with respect to alternatives strategies for managing stocks and fishery effort.

The overall objective of this paper is to identify the main problems of regulation, by consulting different perspectives from the fisheries sector of the Brazilian society. It also reports the main policies of Brazilian government concerning sardine fishery regulation. The focus of the paper is on the main problems identified along the Southern Coast of Brazil concerning the regulation of the fisheries.

## 2. HISTORY OF THE FISHERY AND REGULATION

The fishery of the Brazilian sardine, *Sardinella brasiliensis*, is considered the most important capture fisheries of Southern Brazil, extended from 22º to 29º S (Figure 1). First records of this fishery were dated from 1910; engine-powered boats began operating in the late 1930s, but it has been an industrial activity only since 1964, after which it showed rapid increases in catches.

[1] Instituto de Pesca, Av. Bartolomeu de Gasmao, 192, Ponta da Praia. Santos. SP Brasil 11.030-906. Email: ipescapm@eu.amsp.br

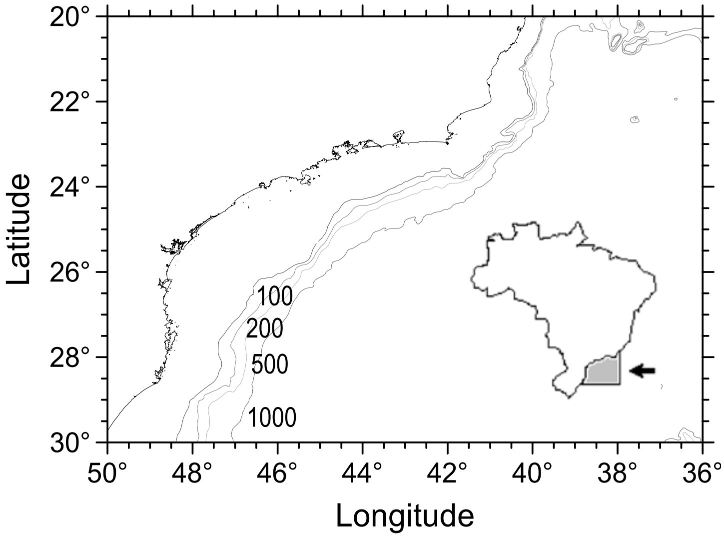


**Figure 1. South-eastern Brazilian Bight**

In the early seventies, government subsidies stimulated fisheries investment. In 1973, sardine landings reached about 228 kt, after which catches trended downward until the 1990s (Figure 2). Between 1975 and 1987, production values oscillated about 128 kt, and between 1988 and 1996, medium values reached only 65 kt. In 1988, sardine stock collapse was already recognized, and technical working groups proposed severe recommendation for fishery management (Rossi-Wongtschowski *et al.,* 1995; SUDEPE/PDP, 1989). Catches have shown some signs of recuperation after the lowest point of 32 kt in 1990.

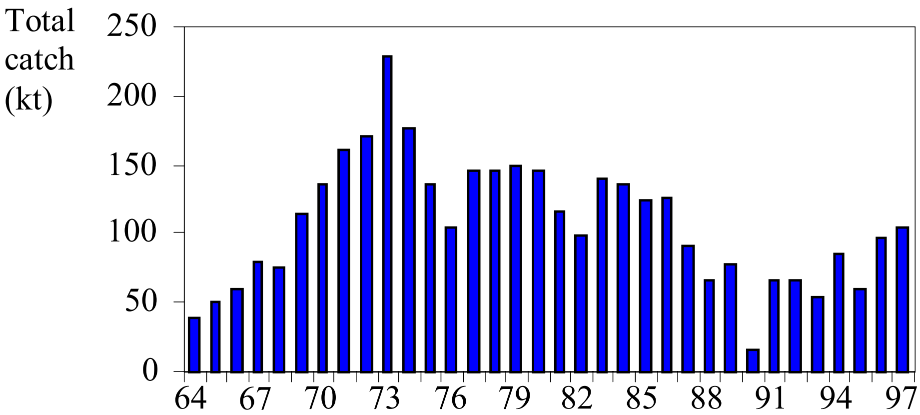


**Figure 2. Recorded catches of Brazilian sardine (*Sardinella brasiliensis*).**
**(Source: SUDEPE, IBAMA, Instituto de Pesca).**

One limitation of the analysis was that effort measures were not continuously collected along the main landing points of the coast, and data are restricted to the period 1974-1983. The change in CPUE (in number of hauls) over this period is showed in Figure 3. The fisheries statistics collapse in the 1980s was due to the heterogeneity of catch information collection along all sardine fishery ports and the lack of human and financial resources.[2] This

[2] Even though statistics re-organization was a permanent concern, as well as scientific cruises for the stock biomass evaluation and oceanographic features variations, it was not continuous and systematically approached (IBAMA/CEPSUL, 1991a, 1991b, and 1993; SUDEPE/PDP, 1981, 1983, 1985, and 1989).

scenario did not allow CPUE trends to be correlated with fishing power variations (IBAMA/CEPSUL, 1991b).

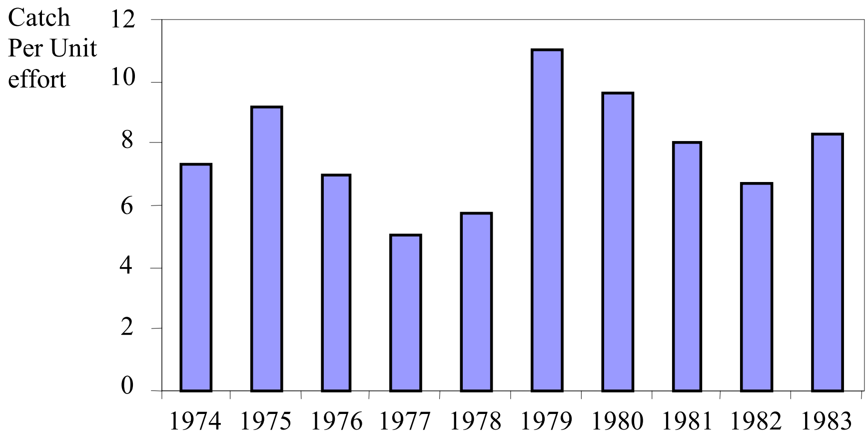


**Figure 3. Evolution of CPUE of Brazilian sardine (*Sardinella brasiliensis*)**
**(Source: SUDEPE, IBAMA, Instituto de Pesca).**

During the period 1974-1976, it was observed that the resource abundance (indicated by CPUE) decreased while effort increased, with a critical situation in 1976 when the total catch was the lowest over the 1974-1983 period. This trend is observed in the two following years, with the highest fishing effort levels observed in all registered fishery period (Figure 4).

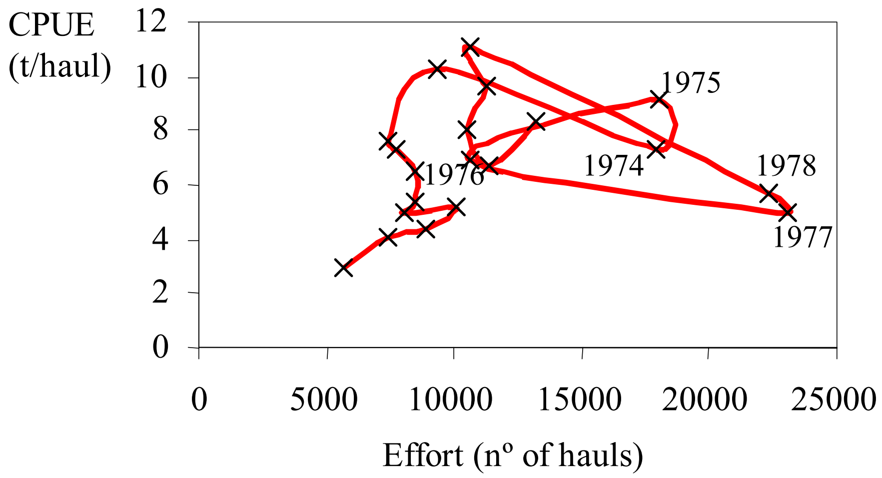


**Figure 4. Relation between CPUE and effort (in number of hauls)**
**(Source: SUDEPE, IBAMA, Instituto de Pesca).**

The sardine fleet size had increased irregularly, with continuous fisheries licence concessions. Unlicensed fishing has been reported only since 1989 (Table 1), although some boats have subsequently received licences. Unlicensed fishing vessels have been excluded from the fishery since 1991. Since the 1970s, the fleet has shown some technological evolution (Table 2) with a 300 percent increase of gross tonnage until the 1990s (IBAMA/CEPSUL, 1994). After 1988, auxiliary equipment, such as sonar and “power block”, was introduced. However, the relationship between modernization and fishing power was not measured (IBAMA/CEPSUL, 1991b).

*Table 1. Sardine fleet size in number of boats (RJ – State of Rio de Janeiro; SP – State of São Paulo; SC – State of Santa Catarina).*

| Year | With licence | | | | Without licence | Observations |
|---|---|---|---|---|---|---|
| | RJ | SP | SC | Total | | |
| 1977 | 91 | 36 | 36 | 163 | -- | > 20 GT |
| 1982 | 154 | 89 | 106 | 349 | -- | All boats |
| 1983 | 137 | 94 | 85 | 316 | -- | All boats |
| 1989 | 105 | 113 | 99 | 317 | 257 | All boats |
| 1990 | 108 | 112 | 104 | 324 | 80 | All boats |
| 1991 | 131 | 114 | 107 | 352 | 0 | All boats |

Source: IBAMA, 1997; IBAMA/CEPSUL, 1991a, 1991b, 1993, 1994; SUDEPE, 1977; SUDEPE/PDP, 1983.

*Table 2. Sardine fleet characteristics, average values.*

| | Gross Tonnage | Horsepower | Total length (m) | Age |
|---|---|---|---|---|
| 1977* | 55.10 | 251.00 | -- | -- |
| 1982 | 40.00 | -- | 16.78 | 17 |
| 1990 | 54.75 | 244.42 | 19.96 | -- |
| 1991 | 55.00 | 243.77 | 19.45 | -- |
| 1992 | 55.30 | 244.80 | 19.50 | -- |

* Only boats bigger than 20 GT. Source: IBAMA, 1997; IBAMA/CEPSUL, 1991a, 1991b, 1993; SUDEPE, 1977; SUDEPE/PDP, 1983.

A review of federal policies, recommendation of technical working groups and effective closure periods for the 20 years of sardine fishery is given in Table 3. Regulatory policies included limiting licences, closure period for spawning, minimum length size and a later closure for recruitment after collapse. It can be noted that recommendations were partially taken into account in the official regulation and its effective complement.

*Table 3. Fisheries policies concerning regulation of the sardine fishery, 1977-1997.*

| Year | Policies | Recommendation of technical working groups | Effective closure periods[a] |
|---|---|---|---|
| 1977 | 40 day closure for spawning (1978)<br>60 day closure for recruitment (1978)<br>Legal minimum length (17 cm)<br>Limiting fleet size | | |
| 1980 | | Maintain fishing effort at present levels<br>Keep spawning closure in 1981<br>Keep minimum length | |
| 1981 | | Maintain fishing effort at present level<br>Keep spawning closure in 1982<br>Keep minimum length (17 cm)<br>Implement licenced fleet study<br>Improve fisheries statistics | |
| 1983 | Licence to pole and line vessels | Maintain fishing effort at present level<br>Keep spawning closure in 1984<br>Keep minimum length (17 cm)<br>Continuous study of licensed fleet<br>Implement study on fishing power determination<br>Continue to improve fisheries statistics | |
| 1984 | Limiting fleet size<br>Establishment of licensing policies<br>Tolerance of 15% of catch <17 cm | | January |
| 1985 | Spawning closure in 1986<br>Licences to pole and line vessels | Maintain fishing effort at present level<br>Spawning closure between 20/12/86-31/1/87<br>Keep minimum length (17 cm)<br>Continuous study of licensed fleet<br>Continue to improve fisheries statistics | |

*Table 3. (continued)*

| Year | Policies | Recommendation of technical working groups | Effective closure periods[a] |
|---|---|---|---|
| 1987 | Tolerance of 15% of catch <17 cm | 40 day closure for spawning between January and February<br>Stop new licences<br>Ban non-purse-seine licences<br>Improve enforcement of juvenile commercialization | January |
| 1988 | Spawning closure in 1989 | | January |
| 1989 | Give licences for unregulated boats | Continue spawning closures as before<br>Keep minimum length (17 cm)<br>Continue to improve fisheries statistics<br>Strong enforcement<br>Population structure monitoring<br>Hydro-acoustic surveys<br>Direct estimation of spawning stock size | Dec-Jan |
| 1990 | 71 day closure for spawning (1991)<br>92 day closure for recruitment (1991)<br>Revoke licences to pole and line vessels | | Dec-Jan |
| 1991 | 48 day closure for spawning (1992)<br>74 day closure for recruitment (1992) | Keep minimum length (17 cm) with 5% tolerance<br>90 day closure for spawning (1992)<br>90 day closure for recruitment (1992)<br>Continue to improve fisheries statistics | Jan-Feb, July-Aug |
| 1992 | 63 day closure for spawning (1993)<br>74 day closure for recruitment (1993)<br>Revoke licences to pole and line vessels<br>Legal minimum length (17 cm)<br>Tolerance of 10% of catch <17 cm | Keep minimum length (17 cm) with 5% tolerance<br>90 day closure for spawning (1993)<br>90 day closure for recruitment (1993) | Jan, July-Aug |
| 1993 | 80 day closure for spawning (1994) | No recommendations | Jan-July |
| 1994 | 45 day closure for spawning (1994)<br>85 day closure for recruitment (1995) | Ban fishing for a period of no lower than 28 months | Jan-Feb |
| 1995 | Spawning closure in 1996 | No workshop | Jan-Feb |
| 1996 | 135 day closure for spawning (1996) | No workshop | Jan-Feb |
| 1997 | 91 day closure for spawning (1997)<br>Limit permitted fleet size | No workshop | Jan-Feb |

a). Recommendations of technical working groups were obtained from official reports. b) Effective closure periods were estimated from catch statistics. Source: IBAMA, 1997; IBAMA/CEPSUL, 1989, 1991a, 1991b, 1993, 1994; Jablonski, 1998; SUDEPE/PDP, 1980, 1981, 1983, 1985, 1989.

## 3. SURVEY ANALYSIS

Several fisheries sector experts from national and state organizations of Southern Brazil were interviewed in order to identify the factors that have had a major impact on the regulation of fishing capacity. Surveys were conducted in their own working places (i.e. universities, government offices, fisheries cooperatives, associations of fishermen and vessels owners, enterprises, landing points, etc.) using a common questionnaire. The questionnaire included open-ended questions about the experts' opinions on the main problem regarding fisheries regulation and sardine decline and management.

The first aspect of the survey analysis elicited expert's opinion about the major causes of the decline and overfishing of the sardine fishery (Figures 5 and 6). Excessive effort and oceanographic anomalies were the most frequent causes of the catch decline suggested by the experts. The survey results suggest that the excessive fleet size and modernization of the fleet was the main factors responsible for overfishing. This suggests that regulation of fisheries was considered an important issue to the sardine conservation. In terms of measures considered effective to the regulation of sardine, the most important was "limiting the number of fishing units" (Figure 7).

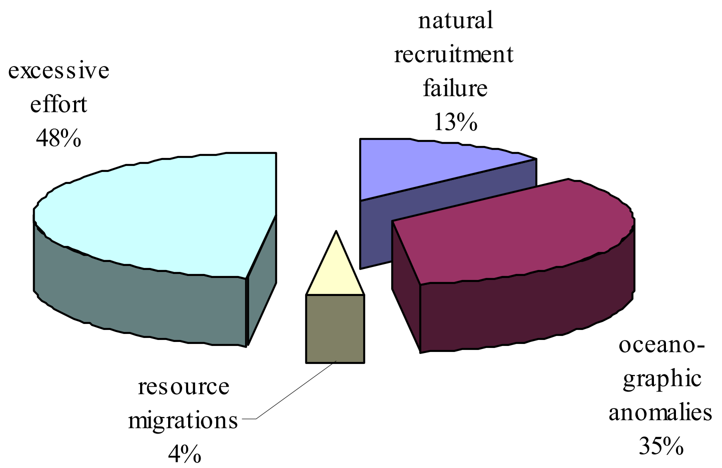


**Figure 5. Major possible causes for the sardine catch decline**

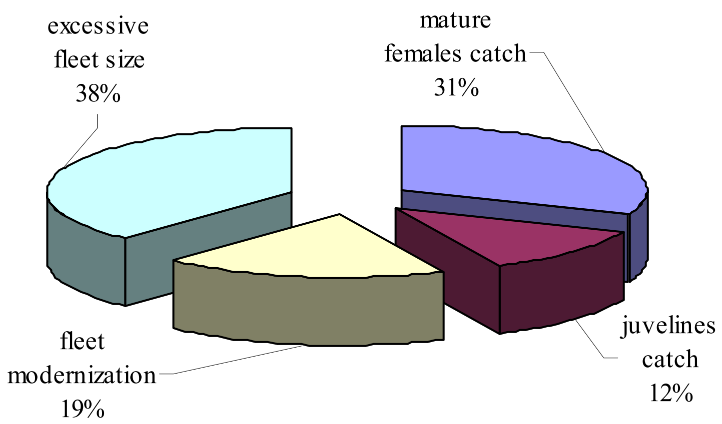


**Figure 6. Major possible causes of the sardine overfishing**

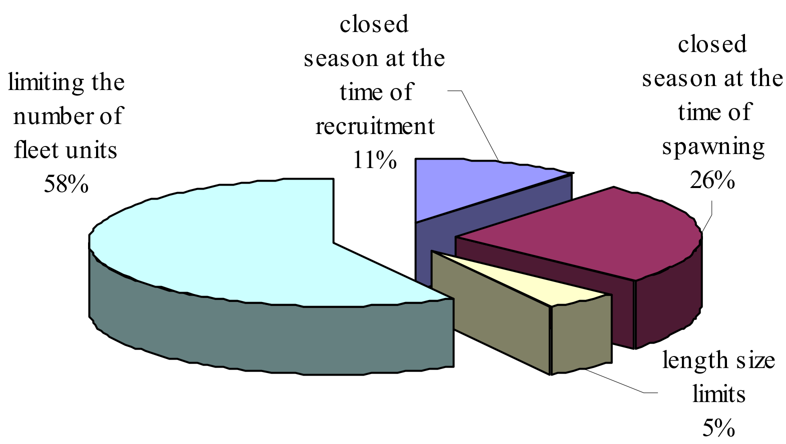


**Figure 7. Main policies considered more effective for regulating fishing effort**

According to the survey, the present regulatory system does not seem appropriate given the actual needs of the sector. Other measures that could be implemented concerning the management of the sardine fishery are presented in Figure 8. A possible allocation of catch quotas seems to be the most popular idea in the fisheries sector.

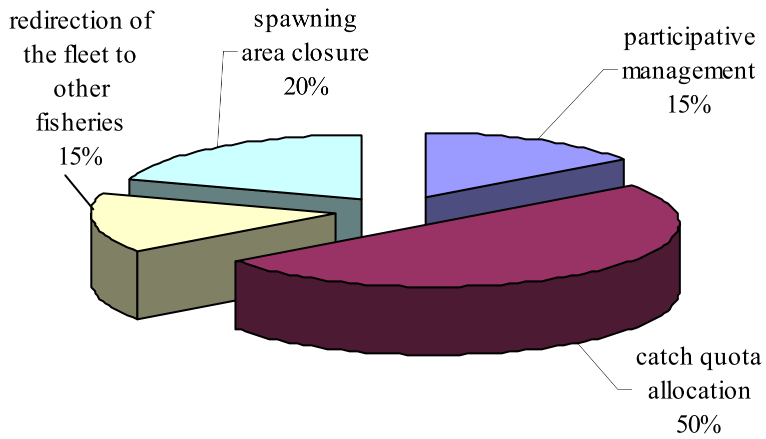


**Figure 8. Main policies that could be implemented for sardine management**

Information on the main constraints to fisheries regulation in Southern Brazil was also collected in the survey. It was found that the main problems pointed out by experts concerned fisheries management, legislation and enforcement (Table 4).

*Table 4. Main problems to fishery regulation in Southern Brazil identified by the survey.*

| Main subject/topic | Major problems |
|---|---|
| *Management* | |
| • Administration Structure | Centralization of responsibilities and regulation at the Federal level |
| | Integration and coordination between Federal, State and municipal government agencies |
| | Structural changes in government institutions responsible for fisheries |
| | Fisheries management does not take into account regional issues |
| | Inflated bureaucratic structure of environmental federal agency |
| | Weak support of productive sector on regulatory measures |
| | Stakeholders fail to appreciate the need for regulation |
| | Failure of fleet regulation; Poor fisheries statistics |
| | Lack of stock monitoring and systematic assessment |
| | Disconnection between scientific progress and decision-making process |
| | Existing rules are impractical to enforce |
| | Legislation failure; Weak enforcement |
| | Management made without a performance evaluation |
| | Lack of monitoring system of fisheries as a whole |
| • Policies | Negligible economic importance of fisheries at the federal level |
| | Lack of participation of the productive sector |
| | Changes in government institutions responsible for fisheries administration |
| | Need for more scientific research-oriented management procedures |
| | Discontinuous research projects |
| | Lack of agreement between user groups |
| | Strong influence of lobbies in the decision making process |
| | Lack of socio-economic analysis and policies |
| | Lack of demand-oriented regulation policies |
| | Stakeholders might pay for the resource and utilization |
| | Need to take into account ecological criteria and ecosystems carrying capacity |

*Table 4. (continued)*

| Main subject/topic | Major problems |
|---|---|
| • Education | Lack of proper education and training of government employees |
| | Need for environmental education (society in general) |
| *Legislation* | |
| • Elaboration | Top-down regulatory model |
| | Dated legislation |
| | Lack of mobilization and participation of society and stakeholders |
| | Lobbies-oriented elaboration process |
| • Basis | Not based on up-to-date scientific research results |
| | Several cautions pointed out by scientists were not contemplated by law |
| | Closures with biological and environmental failures |
| | Time disconnection between science and law |
| | Lack of specific legislation (in terms of biological species) |
| | It is extended out of the reference area |
| • Applicability | Problems concerning complement of law |
| | Lack of socio-economic impact evaluation |
| | Lack of sound structure for the law complement |
| | Lack of an adequate enforcement system |
| *Enforcement* | |
| • Structure | Lack of extensive enforcement |
| | Lack of monitoring of enforcement execution |
| | No participation of Navy in coastal fisheries surveillance |
| | Insufficient enforcement staff |
| • Operation | Lack of training of human resources involved in the process |
| | Regional differences in law interpretation |

Management, legislation and enforcement of fisheries have to be examined in the socio-economic context of the country. Between the present problems of Brazil, the negligible economic importance of fisheries at the national level leads to a potentially unstable system of ineffective fisheries management. An example of this political instability is, in this case, given by the location of fisheries within the government structure. Initially, the Ministry of Agriculture was responsible for fisheries, associated with a development policy of subsidies and fomentation. In the late 1980s, responsibility for fisheries was moved to the National Environmental Agency (IBAMA) (part of the Ministry of Environment) which was mostly concerned with conservation issues. More recently, a Department of Fisheries and Aquaculture has been created, and responsibility for fisheries is back with the Ministry of Agriculture. This generates a crisis in ministerial instances between the two agencies and could lead to a new approach for the activity.

The disconnection between research and other sectors of fishing activity is another important constraint. Failures in the linkage between scientific answers and legislation formulation were observed (see Table 3 and 4). Stakeholders desire a closer relationship between science and commercial activity. Nevertheless, several efforts have been made to construct policy legislation with the aim of regulating fishing activity for sustainable harvests (Table 3).

Another important problem extracted from Table 4 is that stakeholders give little support for regulation due to the perception that the main policies are neither effective nor science-oriented. This reflects the fact that Brazilian society as a whole has poor consciousness and participation in regulation processes.

In this sense, training and education to all players of the fishery sector will be the main perspective to the success of any regulation.

## 4. CONCLUSIONS

Despite the consequences of natural variability of a small pelagic resource, the experience with the Brazilian sardine regulation has shown that the improvement of several points concerning fishery management in Brazil is necessary.

A better definition of management goals, education and commitment will be essential for the improvement of the measure of fishing capacity. It will only be possible when fishery management could transcend a mere technocratic exercise.

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# SOME IMPORTANT FACTORS IN CONTROLLING FISHING CAPACITY IN TUNA FISHERIES

**Ziro Suzuki, Naozumi Miyabe, Miki Ogura, Hiroshi Shono and Yuji Uozumi**[1]

**Abstract**: Evidence from most international tuna fisheries suggest that they are overexploited, with capacity reduction of the order of 20-30 percent required for sustainable production. Although in many cases fleet numbers have been decreasing, the number of hooks used by individual vessels has increased, resulting in a net increase in fishing capacity. For purse seine vessels, the use of FADs has also resulted in an increase in efficiency and thereby fishing capacity. The change in fishing techniques has had a different impact on the species being caught. In particular, the use of FADs increases the catch of juvenile bigeye. As many of these stocks are already overexploited, the use of these devices may further place pressure on these stocks. Management measures have recently been introduced by the International Commission for the Conservation of Atlantic Tunas (ICCAT) to restrict their use to reduce this problem.

## 1. INTRODUCTION

There has been a serious concern about excessive fishing capacity in tuna fisheries, which has led the FAO to take initiative to mediate this problem. One of the tangible actions plans that has emerged from the initiative is the immediate reduction of 20 to 30 percent of fishing capacity of the distant water tuna longline fishery. This reduction is currently being implemented in Japan. However, there is not much action, if any, directed to the reduction of fishing capacity of the tuna purse seine fishery, which dominates the total tuna production. The Inter-American Tropical Tuna Commission (IATTC) has only recently started discussions on fishing capacity of purse seine boats in the Eastern Pacific.

Both the longline and purse seine fisheries, the two major components of the tuna fisheries, are exploiting some tuna species heavily. The size of the tuna taken by the two fisheries tends to differ. The purse seine boats mostly catch juveniles while the longline boats tend to harvest mostly adults. These biological characteristics should be taken into account in assessing overall fishing capacity.

In this paper, important aspects of control of the fishing capacity for tuna fisheries are reviewed with some preliminary analyses for the two major fisheries mentioned above, including trends in fishing capacity, biological and fleet characteristics of tunas and tuna fisheries, estimation of the increase of the fishing efficiency and other relevant subjects to the control of the fishing capacity. The latest information of stock status for some tuna species was used in this study.

## 2 BRIEF REVIEW OF THE RELEVANT STUDIES

A review of the problems regarding fishing capacity measurement methods was made recently by the FAO Technical Working Group on the Management of Fishing Capacity (FAO, 1998). Alternative measurement methods, such as the Date Envelopment Analysis (DEA) and Peak-To-Peak analysis (Kirkley and Squires, 1999), were proposed for future application for fisheries capacity measurement. However, the benefits of such alternative methods seem to require further evaluation before their application to more complicated fisheries. Newton (1999) analyzed the fishing capacity on the high seas using Technological Coefficients, which account for major technological improvement of fishing efficiency. He concluded that a fleet reduction of between 41 and 47 percent was necessary. Suzuki (1999)

[1] National Research Institute of Far Seas Fisheries.

examined overcapacity specific to world wide distant water tuna fisheries, and, by comparing the stock status and current catch levels, estimated that a reduction in fishing capacity in the distant water longline fishery of between 20 to 30 percent was required to ensure sustainable use of the tuna and tuna-like species.

There are relatively few specific studies on fishing capacity or fishing efficiency. This is mostly due to difficulties to collect quantitative time series information about the factors seemingly related to the fishing efficiency. In addition, as later exemplified, there are inherent difficulties to measure overall change in the fishing efficiency.

Pella and Psaropulos (1975) tried to explicitly include the increase of fishing efficiency of the tuna purse seine fleet in the Eastern Pacific in estimating standardized CPUE based on mathematical representation of purse seine operations during 1960-1971. However, the increase of efficiency or real increase of effective fishing effort *per se* during the period was not shown.

Gascuel *et al.* (1993) estimated an increase of overall fishing power, with the use of virtual population analysis (VPA) and general linear modelling (GLM) methods, during the years from 1970 and 1980 for French and Spanish tuna purse seine fleets in the eastern Atlantic. They estimated that fishing powers increased by 17 percent and nine percent on an average for the French and Spanish fleets respectively, and indicated rather complicated pattern of changes in increase or decrease of the fishing power by year or year period and by size of yellowfin. The difference in increased fishing power between the two fleets seemed to reflect fleet-wise difference in operational strategy including target species change.

Recently, Shono and Ogura (1999)[2] analyzed changes in fishing efficiency for skipjack of the Japanese pole and line fishery, by use of the GLM and explicitly accounting effect of use of auxiliary fishing devices such as low temperature bait tank, bird radar, sonar, etc. Although this preliminary study showed relatively small increase in the use of these devices (in the order of ten to 20 percent), the complicated nature of the change in fishing efficiency was revealed. There appeared to be several factors that interacted with the change of fishing efficiency – the efficiency changed with time, area and shift of target species between skipjack and albacore.

Fitzpatrick (1996) estimated technology coefficients by major vessel types by decade from 1965 to 1995. For tuna purse seiners and longliners of 65m vessel length, these coefficients increased from 1.6 in the 1980 period (1976 to 1985) to 2.3 in the 1995 period. However, it was not explained in details how those coefficients were estimated. Three or five percent of annual increase in fishing efficiency due to technological improvement of fishing gears and associated devices has been assumed for French and Spanish Atlantic tuna purse seine fishery although the derivation of these specific values has not been well documented (ICCAT, 1999a). As for the tuna surface fisheries, especially purse seining, rapid and extensive use of artificial fish aggregating devices (FAD), which appears to contribute substantially to increases in fishing power, causes a serious problem in reliable estimate of the fishing effort of the surface gears (ICCAT, 1998).

A cursory review indicates that it is necessary to conduct basic studies to identify factors affecting the increase of fishing power by major tuna fisheries before development of

[2] See also ICCAT (1999).

methods to measure fishing capacity. Other important factors such as multispecies, multigear and international nature of the tuna fisheries should be recognized and somehow included in comprehensive methods for the measurement of fishing capacity.

## 3. MEASUREMENT AND EFFICIENCY INCREASE

### 3.1 Longline fishery

#### *3.1.1 Carrying capacity vs number of hooks*

In spite of the voluntary reduction of the number of the Japanese distant water longline boats that took place in the early 1980s, increases in the number of hooks used by each operation (on average a 20 to 30 percent increase) resulted in a net increase in the total number of hooks used by this fleet segment (Suzuki, 1999). In fact, although the total number and total carrying capacity of the Japanese distant water longline boats has shown a decreasing trend, the total amount of hooks used by those boats has shown an increasing trend.

For Taiwanese distant water longline fishery, the number of boats and carrying capacity has been increasing but the increase rate of total number of hooks is much more rapid than that of the number of the boats or carrying capacity (Dr. S. K. Chang, personal comm.). This implies that an increase of the number of hooks per operation has occurred also for the Taiwanese boats. Therefore, the total number of hooks used is a better index of fishing capacity for this type of fishery.

#### *3.1.2 Improvement of gear technology*

According to the technology coefficient reported by Fitzpatrick (1996), large sized longline boats have increased their fishing power by more than a factor of two during the past 10 years. Since detail of the derivation of this value is not explained, it is impossible to use this value for any specific use. There are no analyses available explaining the technological improvement of fishing efficiency on tuna longline fisheries.

Although, generally speaking, increases in fishing efficiency may occur with the tuna longline fisheries, it is likely that the rate of increase may not be as great as for active fishing gears such as purse seine gear, for example, as the longline method is, by comparison, passive. At any rate, it is recommended that relevant studies of fishing efficiency be undertaken for the longline fishery, considering such technologies as the age of the boats, satellite information on sea and weather conditions and GPS. Until such time as when the more relevant information become available, total number of hooks appears, by default, to be the best indicator of fishing capacity for this fishery.

#### *3.1.3 Multispecific nature*

The longline fishery is essentially a multispecies fishery. This makes measurement of species-specific fishing capacity difficult because the efficiency of longline gear is different depending on the species targeted. For example, Japanese distant water longline boats targeting bigeye in the tropical water especially use so called deep longline to set hooks deeper for the purpose of taking more efficiently the deep swimming bigeye. This commonly used method has opposite effect in fishing efficiency for surface fishing species such as marlins because the hooks are placed mostly out of their vertical habitat. Standardization or measurement of fishing capacity of longline fishing effort should be made species specific to avoid capturing possible false signal from stocks utilized.

## 3.2 Purse seine fishery

### *3.2.1 Factor affecting fishing efficiency*

In the Workshop on Abundance Indices from Tropical Tuna Surface Fisheries (ICCAT, 1998), various factors affecting fishing efficiency were discussed. Although a summary table of the various factors with time series information was shown, no follow-up studies to take these factors into account in the analysis of abundance indices have been made yet.

A study[3] was initiated to apply the GLM method to the Japanese tuna purse seine boats operating in the western tropical Pacific. The aim of the project was to consider several of the factors in abundance indices that appear to have significant effect on fishing efficiency of the tuna purse seine fishing. Major factors selected for the study include bird radar, sonar, school type, net size, power block, purse winch, age of ship, GPS, etc., along with the usual factors such as time, area and year effects. Preliminary results from the study suggest that several factors have highly significant effects on CPUE, although these results are not definitive due to the complicated nature of the analysis and the use of only Japanese boat data. Among the significant factors, it was noted that type of schools (schools associated with floating objects vs free swimming schools) was one of the highest factors that affect CPUE both for yellowfin and skipjack, with higher CPUE being found for sets on schools associated with floating objects. This has a significant implication regarding recent development of the FAD (fish aggregation devices) operations in measuring fishing capacity of the purse seine fleets, as will be further discussed later in this paper.

### *3.2.2 Use of FADs*

The use of FADs has had a dramatic effect on the fishing efficiency of the purse seine fleet. As will be mentioned later, this practice has implications not only for the purse seine fishery but also for the longline fishery. FADs were generally introduced into purse seine fisheries around the start of the 1990s. The introduction took place on a worldwide scale with only a minor difference in the starting year and magnitude of deployment by the different fishing nations.

There are two major advantages of using FADs – creation of new fishing grounds where no opportunities of successful fishing existed in the past; and increases in catch rates within the current fishing grounds due to high successful set rates compared to that for free swimming schools.[4] New FAD fishing grounds, formed outside of the current fishing grounds in the tropical waters, usually produce congregations of juvenile tunas, i.e. skipjack, yellowfin and bigeye. Therefore, since the introduction of FAD fishing, catches of these three species in the Atlantic and Indian Ocean tuna purse seine fishery has increased by a factor of three for bigeye and 1.5 for the other two species (ICCAT, 1999a; IOTC, 1998) despite of relatively stable carrying capacity after mid 1980s (Suzuki, 1999). In the eastern Pacific IATTC area,

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[3] Undertaken by scientists from the National Research Institute of Far Seas Fisheries, Japan.
[4] No substantial difference were noticed in catch rates between the two types of schools.

the overall carrying capacity of purse seine boats has been more changeable in the past decade. However, catches per ton by species show similar magnitude of increase for bigeye and skipjack (IATTC, 1998). As for yellowfin, however, there appears to be no appreciable change in catches per ton in the IATTC area before and after the FAD operations. Although the reason for this is unknown, this might be related to the dolphin regulations in that area.

In the western Pacific, the FAD operation by the purse seine boats has not been as widespread as in other Oceans. However, the FAD operations have increased substantially from 1996, especially for the US boats, which increased the bigeye catch by purse seiners to a record high in 1997. The use of FADs was maintained in 1988, although the bigeye catch declined (Hampton *et al.,* 1999).

### *3.3.3 Multispecies nature*

How to manage mixed species with different stock exploitation conditions is a common problem in fisheries. Bigeye is by-catch for purse seine boats, and has only minor share in the total purse seine catch, which is dominated by yellowfin and skipjack. However, the use of FADs caused concerns for management of world bigeye stocks that have already been overfished. On the other hand, skipjack stocks appear to be either underexploited or moderately exploited and yellowfin stocks either moderately exploited or fully exploited except for western Pacific stock (Suzuki, 1999). As far as the FAD operations are concerned, it is not possible at present to avoid bigeye catch.

## 4 STOCK STATUS AND MANAGEMENT MEASURES

There is no substantial update for stock status of the tuna and tuna-like fish from the summary given by Suzuki (1999). However, a few new management measures have been introduced recently. Quotas on yellowfin tuna were resumed in 1998. In 1999, IATTC introduced regulations to prohibit the use of FADs by purse seine boats after 40 000 tonnes of bigeye had been caught. In addition, the previously voluntary time/area closure by purse seiners for the use of FADs became mandatory for the contracting countries. Prohibition of FAD fishing was proposed by the tropical tuna group of the IOTC to reduce exploitation on bigeye stock in the Indian Ocean.

The western and central Pacific yellowfin and skipjack stocks are considered to be underexploited. However, some concern has been expressed about rapid increase of exploitation rate (up to about 0.4) in nursery ground of yellowfin in the Philippines water (Hampton *et al*., 1999). In the Atlantic, some concern was raised for possible local overexploitation of the skipjack (ICCAT, 1999b).

## 5. CAPACITY CONTROL OF PURSE SEINE FISHERY

While the purse seine vessels target less heavily exploited stocks such as skipjack and yellowfin, it should be noted that the FAD operation *per se* could give much higher potential to purse seine fishing capacity than previously thought, as was demonstrated in the various part of the Oceans. In addition, an urgent problem that needs to be addressed is the assessment of the impact of juvenile bigeye catch on the stock and on the longline fishery targeting mostly adult bigeye.

As purse seine and longline take different size of bigeye, the impact of the two fisheries on the stock will be different. Some conversion factors are needed to calculate the impact to be used as a single value. One way is to calculate the impact of the respective catches on the spawning biomass. In this case, it is obvious that taking juvenile by purse seine boats has higher impact than by longline boats. The magnitude of that differential impact depends on value of age specific natural mortality (M) and ages to reach maturity. Unfortunately, no reliable estimates of age specific M is available. Therefore, it is urgent to address this deficiency.

Furthermore, highly mobile purse seine fleet leave the fully exploited Atlantic, Indian and Eastern Pacific and migrate to the western and central Pacific where the stock status of target species is healthy. The MHLC, an international negotiation body for establishing management measures for highly migratory species in the central and western Pacific by 2000, issued a resolution urging several actions to be taken. Above all, they request that all states and other entities refrain from increasing fishing effort and capacity within that region.

Therefore, it is recommended that the current fishing capacity of the distant water purse seiners should not be increased as a whole and specifically for bigeye, reducing or at least capping juvenile bigeye catch by the use of FADs is desirable.

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# LIMITING THE GROWTH OF THE TUNA PURSE SEINE FLEET FISHING IN THE EASTERN PACIFIC OCEAN

**James Joseph**[1]

## 1. INTRODUCTION

Because of the high market demand for tuna and the increasing levels of fishing effort exerted to fill this demand, nearly all of the world's major stocks of tuna are fully exploited, and some, such as the Atlantic bluefin (*Thunnus thynnus thynnus*) and southern bluefin (*Thunnus maccoyii*) tunas, are severely overexploited. The only region which might support a significant expansion of tuna fishing is the western and central Pacific Ocean, where scientists report that skipjack tuna (*Katsuwonus pelamis*) could sustain greater catches. In other areas tuna fleets are apparently larger than needed to take the available harvest. In most of these fully-exploited areas approximately the same amount of fish could be harvested with less fishing capacity, resulting in lower costs of production, greater economic returns, and lower prices for consumers.

If the stocks of tunas are to be managed and conserved in a rational manner, governments must seek ways to effectively limit the level of fishing mortality applied to the various stocks. To accomplish this over the long term, the number of vessels that can participate in a fishery would need to be limited to a level compatible with the capability of the stock to sustain the desired levels of fishing mortality. Many governments with fleets fishing for tunas are aware of this situation, and have been participating in the FAO initiative to seek means of limiting access to fisheries.

The situation in the tuna fishery of the Eastern Pacific Ocean (EPO) is much the same as in the rest of the world. All of the stocks, with the exception of skipjack, are fully exploited. The international tuna fleet has been growing, and the member governments of the Inter-American Tropical Tuna Commission (IATTC) have taken the first steps to limit the size of the fleet that can fish for tuna in the EPO. This paper reviews activities of the IATTC in this regard.

## 2. THE TUNA FISHERY OF THE EASTERN PACIFIC OCEAN

The fishery for tunas in the EPO, which accounts for about 20 percent of the world production of tuna, occurs between the mainland of the Americas and 150°W from 40°N to 40°S. Yellowfin tuna (*Thunnus albacares*) is the most important species taken in terms of volume of catch, followed by skipjack, bigeye (*T. obesus*), albacore (*T. alalunga*) and bluefin (*T. thynnus orientalis*). Vessels from some 16 nations participate in the fishery, and all types of fishing gear are used, but purse seines accounts for about 85 to 90 percent of the catch. Purse-seine sets on tunas associated with dolphins catch medium to large yellowfin, whereas small yellowfin, skipjack, and small bigeye are taken together in sets on floating objects and on unassociated schools of tunas. Longline vessels catch large bigeye and yellowfin.

The member governments of the IATTC have adopted limits on the purse-seine catches of both yellowfin and bigeye tuna; there are no limits on the catches of bluefin tuna, but the scientific staff of the IATTC has advised that if small bluefin were not harvested, the

[1] Consultant, Inter-American Tropical Tuna Commission.

total catch of that species could be increased. Only skipjack tuna is considered capable of supporting increased yields in the EPO, but to what extent is uncertain.

The IATTC also monitors the catch of marine mammals captured incidentally during tuna-fishing operations. There is an annual limit on the incidental mortality of dolphins, divided among qualified vessels in the form of Dolphin Mortality Limits (DMLs) assigned to individual vessels.

From 1966 through 1979, annual catch limits were set for yellowfin tuna, but in subsequent years the conservation programme lapsed, and as a result the stock was overfished during the late 1970s and early 1980s. A large portion of the fleet left the fishery during the early 1980s, which, together with favourable environmental conditions, permitted the stock to recover by 1985. Between 1985 and 1998, the fishing effort generated by the international fleet did not exceed the level necessary to harvest the average maximum sustainable yield (AMSY) of yellowfin. For yellowfin, the fishing effort required to harvest the AMSY when the population is at its optimum size is about 20 000 to 22 000 standard days.[2] At that size there would be no need to implement catch limits as long as the effort does not exceed that level. Since 1989, the effort has ranged between 20 000 and 27 000 standard days, and the purse-seine catch of yellowfin has averaged approximately 250 000 tonnes.[3] In 1997 the total catch of all tunas taken by the purse-seine fleet reached 470 000 tonnes. The 1999 catch, as of November 8, was about 570 000 tonnes, the highest level in the history of the fishery. The effort generated to achieve the 1997 catch was about 24 000 standard days, a little above the optimum for yellowfin, but the stock was slightly above the level that would produce the AMSY at the beginning of the year. During 1998, fishing effort increased, and in late November the yellowfin fishery in the Commission's Yellowfin Regulatory Area (CYRA)[4] was closed to unrestricted fishing for the rest of the year.

When the fishery for yellowfin in the CYRA is restricted, fishing for that species must cease in the restricted areas, and when the limit for bigeye is reached, all fishing for tunas associated with floating objects is prohibited throughout the EPO. Only vessels with DMLs have the option of fishing in offshore areas for large yellowfin associated with dolphins; other vessels have to either fish for small yellowfin not associated with dolphins or floating objects, which are not abundant in the unrestricted offshore area, or fish for skipjack, or transfer to areas outside the EPO. Unrestricted fishing for skipjack is complicated by the fact that much of the catch is mingled with yellowfin and bigeye; transferring effort to other areas would cause problems because the stocks of tunas in those areas, with the possible exception of skipjack in the western and central Pacific, are all fully exploited.

As the fleet in the EPO grows, and the need to restrict fishing effort increases, it will become more and more difficult to implement effective limits on fishing. Prompted by increasing demand for fish and falling catch rates, the fishing industry will likely pressure governments to not impose limits on its ability to fish. This has happened before in many fisheries throughout the world, and has led to the overexploitation of a number of important fish stocks.

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[2] To permit comparisons of different sizes or classes of vessels, the catching efficiencies of vessels of all sizes are standardized to that of a Class-6 (>363 tonnes carrying capacity) purse-seine vessel, and expressed in standard days.

[3] All tonnages are expressed in metric tonnes.

[4] The inshore area of the EPO between 40°N and 30°S, reaching out to between about 90° and 120°W at different latitudes.

Almost the same situation occurred previously in the tuna fishery of the EPO. In 1966, the governments with vessels participating in the fishery implemented a conservation programme for yellowfin in the EPO, in the form of an annual total allowable catch. The programme was quite successful in maintaining a high abundance of yellowfin until the mid-1970s, when the growing size of the fleet began to cause problems. In 1970, the capacity of the international purse-seine fleet[5] in the EPO was about 60 000 tonnes, and the catch of yellowfin averaged about 100 000 tonnes. The demand for tuna for canning and the prices paid to fishermen were increasing. This stimulated the building of new vessels, and the capacity of the fleet increased to about 160 000 tonnes by 1976, and 170 000 tonnes by 1981 (Figure 1). Prior to 1975, the fleet had been concentrating on large yellowfin associated with dolphins, and the average weight of the fish in the catch was about 12 kg. After peaking at 240 000 tonnes in 1976, the catch began to decline.

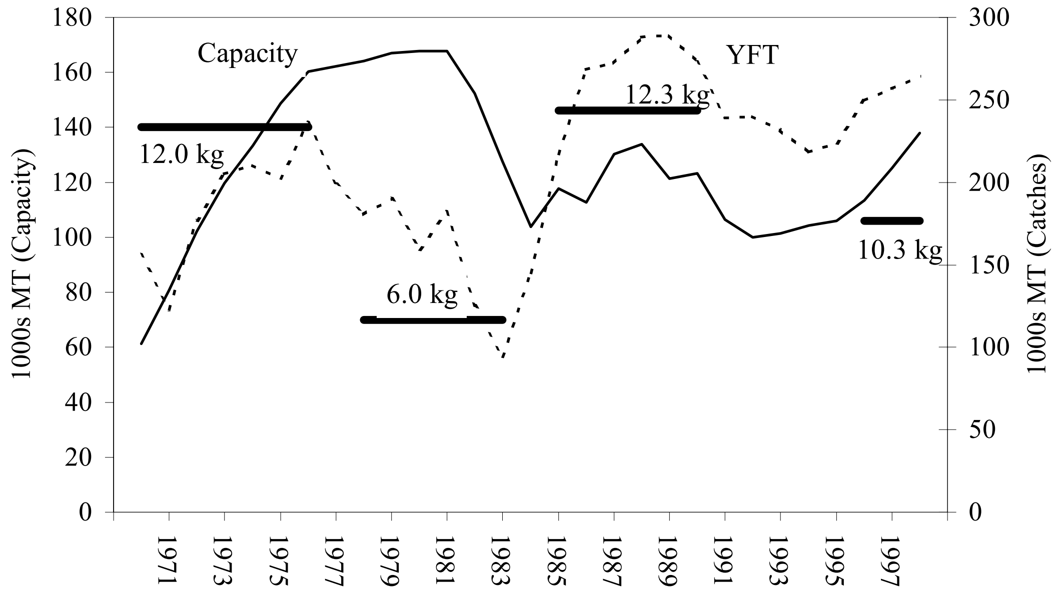


**Figure 1. Total capacity of purse seine vessels, and catch and average weight of yellowfin (YFT).**

As the capacity of the fleet grew and competition for fish increased, vessels concentrated increasingly on tuna not associated with dolphins, and the size of fish in the catch declined, averaging about six kg between 1977 and 1983. This decrease in the average size of yellowfin taken in the fishery caused a decrease in the yield per recruit and a corresponding decrease in the population abundance and productivity of the stock. With the increasing size of the fleet the recommended closure date for unrestricted fishing came earlier in the year, and as the catch declined further, it became more and more difficult for the governments to reach agreement on closing the fishery to unrestricted fishing. By 1980, the catch had declined to 160 000 tonnes, and by 1982 to 125 000 tonnes, even though fishing effort was at its highest level ever, at nearly 38 000 standard days. In 1982, because of the poor catches, vessels began to leave the EPO for the western Pacific, while others stayed in port because catch rates were so low that it was not profitable for them to go fishing. Fishing

[5] The IATTC considers a vessel's *carrying capacity* to be the maximum tonnage of tuna it can hold in its freezing wells, and the total carrying capacity of a fleet to be the sum of the carrying capacities of all of the vessels in that fleet.

effort was much lower between 1983 and 1985, allowing the yellowfin stock to recover to greater levels of abundance.

## 3. THE IATTC WORKING GROUP ON FLEET CAPACITY

From 1986 to 1996 the capacity of the purse-seine fleet in the EPO averaged about 110 000 tonnes; catches of yellowfin were high, averaging about 260 000 tonnes, and the size of the fish in the catch averaged about 12 kg (Figure 1). However, during the mid-1990s the fleet once again began to grow, through the construction of new vessels and the transfer of vessels from other regions. By the end of 1997, the fleet reached 139 000 tonnes of capacity. Fishing on tunas not associated with dolphins began to increase, and the average size of yellowfin in the catch declined. The situation was reminiscent of that of the late 1970s and early 1980s, and created concern among the governments with fleets operating in the EPO. This concern led to a resolution, adopted at the 61$^{st}$ meeting of the IATTC in June 1998, establishing a working group to examine options for limiting the growth in capacity of the international tuna purse-seine fleet operating in the EPO. In formulating its recommendations for any such measures, both interim and long-term, the working group was instructed to take into account the legitimate interests and rights of coastal states and the operational capacity of each fleet then operating in the EPO, with due consideration of historical participation in the fishery.

In September 1998, the working group recommended a series of measures for limiting the growth in the capacity of the fleet in the EPO. On the basis of these recommendations, at its 62$^{nd}$ meeting in October of that year, the IATTC approved a second resolution establishing limits on the capacities of national fleets operating in the EPO during 1999 (Annex 1).

This second resolution set limits, measured in tonnes of carrying capacity, on the size of the tuna fleet that each participating nation could operate in the EPO. The preamble to the resolution states that “the limit established for each state takes into account various factors including: the catch of national fleets during the period 1985-1998; the amount of catch historically taken within the zones where each state exercises sovereignty or national jurisdiction; the landings of tuna in each nation; the contribution of each state to the IATTC conservation programme, including the reduction of dolphin mortality; and other factors.” The capacity of the national fleets during 1985-1998 was apparently the factor given most weight. In paragraphs 3 and 4 of the resolution, special provisions were made for certain states in the process of developing their tuna fisheries, particularly with reference to their legitimate rights under international law.

This resolution applied for 1999 only. However, the governments of the IATTC agreed that the working group should continue its work, and it met in October 1999 and will hold its next meeting on January 26-28, 2000, in San Jose, Costa Rica. In preparation for this meeting, information on the characteristics of the fishery is being compiled by the IATTC staff for the working group to use in its efforts to arrive at a means of effectively controlling growth in the fishery. Some of this information is presented below.

### 3.1 Special problems being considered by the IATTC working group

Catch limitations, such as quotas and area and season closures, have been commonly used to manage tuna fisheries in the past. Their success has been limited in some cases because there have been no controls on the number of vessels that could share in the quota or fish in an area or season. The consequence has often been unchecked fleet growth, resulting from the desire of individuals or nations to take greater shares of the available catch. As fleets grow and competition among vessels increases, creating economic problems for the vessel owners, there is greater pressure to weaken conservation controls. This can lead to the failure of conservation programmes, as in the case of the EPO fishery in the 1980s. If quotas and season and area closures are to be effective, they need to be coupled with restrictions on the number of vessels that can operate in the fishery. Indeed, in some situations, if fleet size is adequately controlled, other restrictions such as quotas and seasons may not be needed.

There is unfortunately little actual experience to refer to regarding limiting the size of a fishing fleet operating in a multinational fishery. However, the two most important points that must be taken into account when formulating ways of limiting fishing capacity are legal and technical considerations.

As regards legal considerations, international law or customary practice regarding the ocean and its resources provide little practical guidance on how to deal with the problem of limiting fishing capacity or catches in a multinational fishery. The United Nations Convention on the Law of the Sea (UNCLOS), in particular Article 62, outlines some of the rights and responsibilities of coastal states, particularly with respect to their ability to utilize the resources within their jurisdictions. If a coastal state cannot utilize the total allowable catch (TAC) within waters under its jurisdiction, then it shall, under certain conditions, provide access to other nations to utilize the surplus. Article 64, which deals with highly migratory species, calls on nations to work jointly in the scientific study and management of these species. The drafters of the Convention realized that the migratory nature of the tuna and tuna-like species meant that they could not be effectively managed by any one nation, but that all coastal and distant-water fishing nations which participated in the fishery for tunas would have to work together to ensure the rational utilization and conservation of the species. Likewise, the 1995 United Nations “Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks” outlines a number of rights and responsibilities regarding the exploitation and management of tuna and tuna-like species, and defines a number of important points regarding the sharing of marine resources, but does not specifically define the rights of coastal and distant-water states in allocating those resources.

As regards technical considerations, the first priority is to determine the desired objective. This may be to optimize sustainable catches by constraining the amount of fishing mortality that can be exerted on a stock of fish, as in the case of the IATTC conservation programme, but it could also be to optimize economic returns from the fishery.

Fishing mortality, along with natural mortality, affects the abundance of the species being exploited, but it is difficult both to estimate and to control. Fishing mortality is defined as the product of fishing effort and a numerical constant representing the proportion of a population being exploited which is removed by a defined unit of fishing effort. This numerical constant, the *fishing power* of the vessel, is affected by the influence of the environment on the behaviour of the fish, which complicates efforts to limit fishing mortality by controlling fleet size. Fishing power is also affected by improvements in fishing gear and techniques, and can vary with the size and characteristics of the vessel. In the tuna purse-seine fishery of the EPO, vessels with different characteristics are standardized to one type of vessel, and it is therefore theoretically possible to quantify the amount of fishing mortality a particular sized fleet could generate. However, it is also necessary to monitor the efficiency of a fleet through time to quantify any changes in fishing power.

Because fishing mortality is so difficult to measure, a vessel's fish-carrying capacity, which is considered to be proportional to fishing mortality, is often used as a substitute. This is the approach used by the member governments of the IATTC, and in other fisheries in which attempts to limit fishing mortality have been made. There are different definitions of a vessel's capacity -- the term can refer to displacement tonnage, net registered tonnage, gross tonnage, fish-carrying capacity, or the tonnage of fish it can carry in its freezing wells -- but is usually related in some way to the size of the vessel.

## 3.2 Criteria for allocating capacity limits in the EPO

As is evident from the IATTC resolution on limiting fleet capacity, any system for limiting the size of the international fleet in the EPO will probably, but not necessarily, involve some form of partitioning the total limit among nations. There are many ways of doing this, from limiting the capacity of the fleet to its present level and distributing that capacity among nations, to partitioning fleets among nations according to some measure related to the economic level of the nations. However, there are many possible approaches to the allocation of capacity limits: for instance, a mechanism similar to that used for DMLs, which are assigned to vessels and remain with the vessel if it changes flag, could be used. In its efforts to resolve this problem, the IATTC has been examining a variety of data related to fishery and the nations involved; some of the information being examined by the working group and the member governments is discussed in the following paragraphs.

### *3.2.1 Catches and landings*

The catches, by species and flag, and landings, by species and country or region, of tunas from the EPO by surface fishing vessels for 1998 are shown in Table 1. Similar data are available in IATTC records dating back more than fifty years. The catches represent the fish captured by and loaded aboard surface-fishing vessels (purse-seiners, baitboats, and other types of gear other than longlines) in the EPO in that year. Landings are the catches unloaded in that year, and may include fish caught in the previous year. The country or region of unloading is the destination for consumption or final processing (*e.g.* canning) of the fish. It is clear from this table that significant quantities of tuna are unloaded and canned or processed into loins in nations with small fleets or no fleets. In other cases, nations have large catches but no landings, indicating that none of the fish is processed in that nation but is sold in other nations for processing. Some nations have both large catches and large landings, demonstrating the importance of the fishery to their economies.

### *3.2.2 Processing capacity*

It is apparent from Table 1 that some nations only catch tuna in the EPO, others only process tuna caught in the EPO, and others do both. Information on the number of tuna canneries in each nation is listed in Table 2. This information, although incomplete, gives some idea of the relative importance of the fisheries for some states. Information on the amount of tuna from that EPO processed at each cannery and the number of persons employed in each cannery, which would be very useful for evaluating the importance of the fishery to a state's economy, is not available in IATTC records, but could be obtained.

*Table 1. Estimates, in metric tonnes, of catches by species and flag, and landings, by species and country or region, of tunas caught by surface gear in the eastern Pacific Ocean, 1998.*

| Flag | Yellowfin | Skipjack | Bigeye | Bluefin | Bonito | Albacore | Black skipjack | Other tunas | Total |
|---|---|---|---|---|---|---|---|---|---|
| *Catches* | | | | | | | | | |
| Belize | 3 144 | 3 997 | 1 145 | - | - | - | - | - | 8 286 |
| Colombia | 14 329 | 4 109 | 553 | - | - | - | - | - | 18 990 |
| Cyprus | 19 | 293 | 101 | - | - | - | - | - | 413 |
| Ecuador | 39 435 | 68 797 | 20 203 | - | - | - | 261 | 23 | 128 719 |
| El Salvador | 1 330 | 317 | - | - | - | - | - | - | 1 648 |
| Honduras | 869 | 629 | 142 | - | - | - | - | - | 1 639 |
| México | 108 082 | 18 208 | 135 | 1 | 412 | 8 | 85 | 61 | 126 993 |
| Panamá | 5 114 | 1,990 | 54 | - | - | - | 9 | - | 7 167 |
| Spain | 5 594 | 19 199 | 5 462 | - | - | - | - | - | 30 255 |
| Taiwan | 21 | 57 | 32 | - | - | - | - | - | 111 |
| United States | 5 917 | 8 761 | 3 432 | 1 842 | 924 | 116 | 75 | 11 | 21 078 |
| Unknown | 194 | 604 | 267 | - | - | - | - | - | 1 066 |
| Vanuatu | 18 496 | 11 318 | 3 590 | - | - | - | 7 | - | 33 410 |
| Venezuela | 63 500 | 6,074 | 236 | - | - | - | 72 | 9 | 69 891 |
| Total | 266 044 | 144 354 | 35 352 | 1 843 | 1 336 | 124 | 510 | 104 | 449 668 |
| *Landings* | | | | | | | | | |
| Colombia | 48 629 | 14 118 | 2 900 | - | - | - | - | 20 | 65 667 |
| Costa Rica | 27 225 | 2 891 | 443 | - | - | - | - | - | 30 561 |
| Ecuador | 53 209 | 88 057 | 26 629 | - | - | - | 268 | 22 | 168 188 |
| México | 96 862 | 16 929 | 79 | 34 | 412 | 8 | 85 | 61 | 114 472 |
| Nicaragua | - | - | - | - | 25 | - | - | - | 26 |
| Panamá | 3 617 | 982 | 316 | - | - | - | - | - | 4 915 |
| Perú | 936 | 21 | - | - | - | - | - | 9 | 966 |
| Spain | 5 858 | 4 905 | 1 956 | - | - | - | - | - | 12 720 |
| United States | 3 915 | 6 006 | 1 785 | 1 694 | 757 | 105 | 75 | 10 | 14 351 |
| Unknown | 1 032 | 165 | - | 114 | 141 | 8 | - | - | 1 461 |
| Venezuela | 27 250 | 1 861 | 88 | - | - | - | - | - | 29 199 |
| Total | 268 536 | 135 938 | 34 199 | 1 843 | 1 336 | 123 | 429 | 123 | 442 530 |

*Table 2. Number of principal tuna canneries, by country*

| Country | Number |
|---|---|
| Colombia | 6 |
| Costa Rica | 4 |
| Ecuador | 18 |
| El Salvador | 1 |
| France | 12 |
| México | 17 |
| United States | 5 |
| Venezuela | 15 |

### *3.2.3 Capacity of fishing fleets*

The IATTC considers a vessel's *carrying capacity* to be the maximum tonnage of tuna it can hold in its freezing wells, and the total carrying capacity of a fleet to be the sum of the carrying capacities of all of the vessels in that fleet. The total carrying capacity of the international purse-seine fleet in the EPO tuna fishery in 1992 was about 100 000 tonnes. By

1997, carrying capacity had increased to about 125 000 tonnes. This increased again in 1998 and 1999 to 139 000 tonnes and 153 000 tonnes respectively.

The IATTC staff uses the following methods to determine the carrying capacity of individual vessels or fleets of vessels. When a new or recently reconstructed vessel first joins the EPO fleet, its initial total carrying capacity is determined from information obtained from the shipyard that constructed or most recently modified the vessel or, more frequently, from the vessel owner or crew; this may be an estimate based on shipyard rated capacity or on previous unloadings in other ocean areas. Once the vessel is included in the EPO fleet, its unloading records are examined at the end of each year. If an unloading record exceeds the initial or current carrying capacity, that unloading record becomes the new carrying capacity of the vessel. The total capacity of the fleet for a particular year is computed by summing the capacity of all vessels that have made at least one unloading in that year of yellowfin and/or skipjack and/or bluefin and/or bigeye from a single trip in the EPO.

The tonnage that a vessel carries depends upon how densely the fish are packed in the vessel's freezing wells, which, in turn, is dependent on the size of the fish in the catch and on market demands for type and quality of the frozen product. This flexibility may lead to situations where vessels with identical well volumes have different "fishing capacities" in the EPO fleet. For example, the owner of vessel A, with a shipyard-rated capacity of 1 200 tonnes, might choose to always load less fish than the vessel is rated to carry, to ensure that the fish are maintained in optimum condition during the loading, freezing, and unloading process. The owner of an identical vessel, vessel B, might decide on one occasion to load the maximum possible quantity of fish, resulting in a landing of 1 200 tonnes. In this example, when unloading data are examined at the end of the year, the capacity of vessel B would continue to be 1 200 tonnes, while that of vessel A would be revised to 1 000 tonnes. This system has proved useful for estimating the "fishing capacity" of the fleet fishing for yellowfin, skipjack, and bigeye, but these variations have caused some problems in computing the assessments paid by vessels participating in the IATTC's observer programme, and would also cause problems in the future if the system were used as a basis for the management of fleet capacity. To avoid this difficulty, the governments decided to use the more objective value of well volume, measured in cubic meters and converted to carrying capacity in tonnes, using an agreed ratio of cubic meters/ton, as a basis of vessel assessments. There would be advantages to using well volume, rather than unloading weights, to compute carrying capacity for the purposes of fleet limitation as well. Data on individual vessel characteristics, including carrying capacity and cannery unloading weights, are available in IATTC records dating back to the early days of the fishery.

### *3.2.4 Catches within Exclusive Economic Zones*

The annual catches of tunas, by species, taken by surface fishing vessels within the Exclusive Economic Zones (EEZs) of states bordering the EPO are available in IATTC records dating back to 1960. For each state, the catch of each species and of all species combined taken in that state's EEZ, and that catch expressed as a percentage of the total catch taken in the EPO, averaged for 1994-1998 are shown in Table 3. These data were compiled by the IATTC staff, using the information currently available on EEZ boundaries, but some boundaries are unresolved.

There are several important points to consider when examining these data. First, there is a high degree of annual variability in the catch of tuna made within the EEZ of any particular nation: for some nations the catches may vary by as much as a factor of five. Second, there has been a downward trend in the percentage of the total catch of tunas taken within the combined EEZs of the EPO and a corresponding upward trend in the catch from international waters, mostly due to the development of the fishery on fish-aggregating devices (FADs) in the offshore area. Third, the catches shown in Table 3 recorded as taken inside the EEZ of a coastal state represent catches made by the international fleet fishing in that zone, rather than just vessels of the corresponding coastal state. In order for the fleet of the coastal state to make those catches in its EEZ, it would have to be capable of generating fishing effort equivalent to that generated by the components of the international fleet fishing in that EEZ.

*Table 3. Estimated average annual catches by surface gear, in metric tonnes, of tunas species within the Exclusive Economic Zones (EEZs) of states bordering the EPO during 1994-1998.*

| | Yelowfin | | Skipjack | | Bigeye | | Bluefin | | All species | |
|---|---|---|---|---|---|---|---|---|---|---|
| EEZ | Catch | % EPO | Catch | % EPO | Catch | % EPO | Catch | % EPO | Catch | % EPO |
| Colombia | 5 007 | 2.1 | 5 227 | 4.1 | 393 | 1.0 | 0 | 0.0 | 10 561 | 2.5 |
| Costa Rica | 14 313 | 5.9 | 1 344 | 1.1 | 40 | 0.1 | 0 | 0.0 | 15 689 | 3.8 |
| Ecuador | 15 438 | 6.4 | 14 754 | 11.7 | 4 467 | 10.9 | 0 | 0.0 | 34 676 | 8.4 |
| El Salvador | 2 918 | 1.2 | 39 | 0.0 | 0 | 0.0 | 0 | 0.0 | 2 941 | 0.7 |
| France | 7 434 | 3.1 | 940 | 0.7 | 22 | 0.1 | 0 | 0.0 | 8 388 | 2.0 |
| Guatemala | 3 311 | 1.4 | 3 | 0.0 | 0 | 0.0 | 0 | 0.0 | 3 312 | 0.8 |
| México | 54 673 | 22.5 | 11 569 | 9.2 | 2 | 0.0 | 847 | 28.5 | 67 465 | 16.3 |
| Nicaragua | 1 200 | 0.5 | 5 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 203 | 0.3 |
| Panamá | 6 293 | 2.6 | 2 707 | 2.1 | 123 | 0.3 | 0 | 0.0 | 9 105 | 2.2 |
| Perú | 5 675 | 2.3 | 3 561 | 2.8 | 306 | 0.7 | 0 | 0.0 | 9 481 | 2.3 |
| United States | 549 | 0.2 | 523 | 0.4 | 5 | 0.0 | 1 695 | 57.0 | 3 010 | 0.7 |
| Within EEZs | 116 813 | 48.1 | 40 653 | 32.2 | 5 174 | 12.6 | 2 542 | 85.5 | 165 832 | 40.0 |
| Total EPO | 243 039 | | 126 341 | | 40 963 | | 2 973 | | 414 347 | |

Notes: Catch: catch within EEZ; % EPO: percentage of the total EPO catch taken in that EEZ; All species: all species caught. Based on data available 27 September 1999.

### *3.2.5 Demographics*

There are wide differences in the populations and economic status of the various states involved in the tuna fishery in the EPO. Some of these differences are apparent from Table 4, which shows data for 1990-1995 on human population, *per capita* gross domestic product (GDP), and growth rates for each of the states bordering the EPO or with fleets fishing for tunas in the area. GDP is expressed in United States dollars and at constant 1990 prices; growth rates are obtained by dividing the GDP of a year by the GDP of the preceding year. The data were obtained from United Nations and World Bank sources.

*Table 4. Population (millions), per capita gross domestic product (GDP), and growth rates of states bordering the EPO or with fleets fishing for tunas in the area.*

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| *Belize* | | | | | | |
| • Population | 0.19 | 0.19 | 0.20 | 0.20 | 0.21 | 0.21 |
| • GDP - per capita | 2 120 | 2 242 | 2 376 | 2 451 | 2 459 | 2 569 |
| • Growth rate | 9.3 | 4.2 | 7.2 | 9.8 | 6.0 | 3.7 |
| *Chile* | | | | | | |
| • Population | 13.15 | 13.37 | 13.59 | 13.82 | 14.00 | 14.21 |
| • GDP - per capita | 2 320 | 2 582 | 3 156 | 3 314 | 3 728 | 4 736 |
| • Growth rate | 3.3 | 7.3 | 11.0 | 6.3 | 4.2 | 8.5 |
| *Colombia* | | | | | | |
| • Population | 33.32 | 34.10 | 34.88 | 35.68 | 35.68 | 36.40 |
| • GDP - per capita | 1 236 | 1 241 | 1 302 | 1 463 | 1 914 | 2 215 |
| • Growth rate | \4.3 | 2.0 | 4.0 | 5.2 | 5.8 | 5.2 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| *Costa Rica* | | | | | | |
| • Population | 3.04 | 3.11 | 3.19 | 3.27 | 3.32 | 3.39 |
| • GDP - per capita | 1 881 | 1 811 | 2 111 | 2 300 | 2 485 | 2 696 |
| • Growth rate | 3.6 | 2.3 | 7.7 | 6.3 | 4.5 | 2.5 |
| *Cyprus* | | | | | | |
| • Population | 0.70 | 0.71 | 0.72 | 0.73 | 0.73 | 0.73 |
| • GDP - per capita | 8 162 | 8 286 | 9750 | 9 086 | 9 924 | 11 459 |
| • Growth rate | 7.3 | 0.6 | 9.7 | 1.7 | 6.0 | 5.0 |
| *Ecuador* | | | | | | |
| • Population | 10.26 | 10.49 | 10.73 | 10.98 | 11.38 | 11.63 |
| • GDP - per capita | 1 041 | 1 119 | 1 178 | 1 303 | 1 480 | 1565 |
| • Growth rate | 3.0 | 5.0 | 3.6 | 2.0 | 4.3 | 2.3 |
| *El Salvador* | | | | | | |
| • Population | 5.17 | 5.29 | 5.40 | 5.52 | 5.39 | 5.48 |
| • GDP - per capita | 1 059 | 1 034 | 1 133 | 1 290 | 1 463 | 1 660 |
| • Growth rate | (3.3) | 3.6 | 7.5 | 7.4 | 6.0 | 6.5 |
| *France* | | | | | | |
| • Population | 56.74 | 57.06 | 57.37 | 57.65 | 57.90 | 58.15 |
| • GDP - per capita | 21 077 | 21 063 | 23 107 | 21 717 | 22 963 | 26 444 |
| • Growth rate | 2.5 | 0.8 | 1.3 | (1.5) | 2.7 | 2.2 |
| *French Polynesia* | | | | | | |
| • Population | 0.20 | 0.21 | 0.21 | 0.22 | 0.22 | 0.22 |
| • GDP - per capita | 14 872 | 14 729 | 15 849 | 16 565 | 16 581 | 19 766 |
| • Growth rate | 4.0 | 3.9 | 1.5 | 2.0 | 3.5 | 2.5 |
| *Guatemala* | | | | | | |
| • Population | 9.20 | 9.47 | 9.74 | 10.03 | 10.76 | 11.06 |
| • GDP - per capita | 832 | 994 | 1 071 | 1 137 | 1 256 | 1 392 |
| • Growth rate | 3.1 | 3.7 | 4.8 | 4.0 | 4.0 | 4.9 |
| *Honduras* | | | | | | |
| • Population | 4.88 | 5.03 | 5.18 | 5.34 | 5.30 | 5.45 |
| • GDP - per capita | 625 | 610 | 660 | 657 | 622 | 697 |
| • Growth rate | 0.1 | 3.3 | 5.6 | 6.2 | (1.5) | 3.6 |
| *México* | | | | | | |
| • Population | 84.51 | 86.27 | 88.06 | 90.03 | 91.59 | 93.32 |
| • GDP - per capita | 2 932 | 3 380 | 3 812 | 4 114 | 4 145 | 2 700 |
| • Growth rate | 4.4 | 3.6 | 2.8 | 0.6 | 3.5 | (6.9) |
| *Nicaragua* | | | | | | |
| • Population | 3.68 | 3.82 | 3.96 | 4.11 | 4.06 | 4.19 |
| • GDP - per capita | 621 | 475 | 489 | 506 | 462 | 464 |
| • Growth rate | 0.0 | (0.2) | 0.4 | (0.4) | 3.3 | 4.2 |
| *Panamá* | | | | | | |
| • Population | 2.40 | 2.44 | 2.49 | 2.54 | 2.57 | 2.61 |
| • GDP - per capita | 2 248 | 2 422 | 2 682 | 2 799 | 2 870 | 2 934 |
| • Growth rate | 7.4 | 7.9 | 7.2 | 4.1 | 3.7 | 3.0 |
| *Peru* | | | | | | |
| • Population | 21.59 | 22.01 | 22.44 | 23.89 | 24.05 | 24.56 |
| • GDP - per capita | 1 674 | 1 940 | 1 873 | 1 770 | 2 164 | 2 497 |
| • Growth rate | (5.4) | 2.8 | (1.4) | 6.4 | 13.1 | 7.0 |
| *United States* | | | | | | |
| • Population | 249.95 | 252.64 | 255.38 | 258.09 | 260.60 | 263.40 |
| • GDP - per capita | 21 604 | 22 033 | 22 890 | 23 888 | 25 127 | 26 037 |
| • Growth rate | 1.2 | (0.5) | 2.5 | 3.4 | 4.1 | 2.0 |
| *Vanuatu* | | | | | | |
| • Population | 0.15 | 0.15 | 0.16 | 0.16 | 0.17 | 0.17 |
| • GDP - per capita | 1 026 | 1 124 | 1 153 | 1 122 | 1 206 | 1 289 |
| • Growth rate | 5.2 | 4.1 | 0.8 | 3.8 | 3.0 | 3.2 |
| *Venezuela* | | | | | | |
| • Population | 19.33 | 19.80 | 20.27 | 20.71 | 21.14 | 21.56 |
| • GDP - per capita | 2 492 | 2 676 | 2,955 | 2 871 | 2 719 | 3 496 |
| • Growth rate | 6.5 | 9.7 | 6.1 | 0.3 | (2.9) | 3.4 |

Note: GDP is expressed in US dollars and at constant 1990 prices; growth rate is obtained by dividing the GDP of that year by the GDP of the preceding year.

## 4. IATTC EFFORTS TO LIMIT FLEET CAPACITY

One of the primary considerations of the member governments of the IATTC for limiting the size of the fleet is that, without such limits, the catches per vessel will decline and the economic pressures on individual vessels will be so great that it would be politically very difficult to sustain an effective conservation programme. It is difficult to determine the size to which a fleet should be limited: ideally, it should be no more than a size that can take the desired harvest from the fishery, while at the same time ensuring the sustainability of each stock. As noted earlier, in the EPO tuna fishery catches of yellowfin and bigeye need to be controlled, whereas skipjack can most likely sustain increased catches. For yellowfin the optimum level of effort (that which could harvest the AMSY with the current distribution of fishing modes) is about 20 000 to 22 000 standard days. This level of effort could also take the maximum recommended catch of bigeye for the surface fishery. It is not possible to estimate the optimum effort for skipjack. However, in 1997, the total catch of all species combined was at an historical maximum, with an effort of about 24 000 standard days. In 1998 effort was greater, but the catches were less than those of 1997; however, as noted above, the 1999 catch of skipjack is already the greatest on record. Although it is still too early to estimate the total fishing effort for 1999, it will probably not be much different from that of 1998. Based on these observations, it would seem prudent to keep the fleet at a size which could generate between 20 000 and 25 000 standard days of effort. At current population sizes, that amount of effort could easily be generated by a purse-seine fleet of no more than 135 000 tonnes of carrying capacity, and most likely significantly less. This assumes that the size composition of the individual vessels in the fleet does not change much; if it did, the effort the fleet could generate would also change because of the differences in fishing power of vessels of different sizes.

Similarly, the efficiency of vessels of any size can be increased by improving fishing equipment and techniques. For example, if a fleet of 100 000 tonnes of capacity (100 vessels of 1 000 tonnes each) capable of generating 22 000 standard days of effort were to improve its efficiency at catching fish by ten percent, the same 100 vessels could generate approximately 24 000 standard days of effort in about the same time it took to generate 22 000 days before the increase in efficiency. Additionally, problems can arise which are related to limitation of size of the fleet. Typically, in the EPO a 600-tonne vessel and a 1 200-tonne vessel have similar fishing power and spend, on average, the same number of days at sea fishing during a year. If a national fleet consisting of ten vessels, each of 1 200 tonnes of capacity, is replaced with a fleet of 20 600-tonne vessels, its capacity remains the same but its fishing power is doubled. Such a situation would defeat the objective of limiting fishing mortality by limiting fleet size. It is, therefore, of utmost importance that in any scheme to limit fleet size the efficiency of vessels be monitored and any change in efficiency be incorporated into the programme.

As mentioned above, there are a number of ways of measuring the size of a fishing fleet, but the method most often used by the IATTC is carrying capacity. An FAO technical working group on the management of fishing capacity which met in La Jolla during April 1998 defined fishing capacity as "*the maximum amount of fish over a period of time (year, season) that can be produced by a fishing fleet if fully utilized, given the biomass and age structure of the fish stock and the present state of the technology. Fishing capacity is the ability of a vessel or fleet of vessels to catch fish*". If the purpose of limiting the size of a fishing fleet is to keep it in balance with the optimum productivity of the populations of fish being harvested, then the ideal approach would be to limit the fleet to a size at which it could generate the optimum annual fishing mortality when all vessels in the fleet fished all year. Doing this for the tuna fishery in the EPO is complicated by the fact that some stocks of fish are fully exploited while others are not. Accordingly, the optimum effort may be different for each stock.

The limits established on fleet size in 1999 by the IATTC resolution (Annex 1) were based on data on carrying capacity, which are available from the earliest days of the fishery. At the time these limits were set, the fleet capacity was about 138 000 tonnes, and the permissible capacity under the resolution was 158 837 tonnes, not including the exceptions listed in paragraphs 2 and 3. The current fleet capacity is 153 000 tonnes and, as noted above, a fleet of 135 000 tonnes of capacity would be capable of harvesting yellowfin and bigeye at recent levels of total catch. The problem facing the Commission is how to reduce the size of the existing fleet, which is already larger than needed to take the allowable catch of yellowfin and bigeye, and at the same time accommodate the desire expressed by many states to increase the sizes of their fleets. This task is further complicated by wide differences in the needs and interests of the various states that already have, or are interested in having, fleets operating in the EPO. Some of these states are coastal and others are not. Some states have long histories of operating in the area with large fleets, others have small fleets but intend to increase them, and others have no fleets, but have an interest in developing them. For some states, the fishery is currently of great economic importance, while other states that have not yet developed fisheries are interest in doing so. Developing a system for controlling fleet capacity that takes all these differences into account will not be easy, but the IATTC will have to find a solution if it is to fulfil its mandate to conserve the tuna stocks of the eastern Pacific.

## APPENDIX 1: INTER-AMERICAN TROPICAL TUNA COMMISSION RESOLUTION ON FLEET CAPACITY (October 1998)

1. *The High Contracting Parties to the Commission:*

   *Seeking to address* the potential problem of excess capacity in the tuna purse-seine fleet operating in the Eastern Pacific Ocean (EPO) by limiting such capacity to a level which, when viewed in relation to other agreed management measures and projected and actual catch levels, will ensure that tuna fisheries in the region are conducted at a sustainable level:

   *Welcome* the commitment by states (both members and non-members of the IATTC) with vessels licensed to fish for tuna in the EPO or with significant installed processing capacity in the region as of June 12, 1998, to move towards this level of fishing capacity by regulating the size of their fleets fishing in the EPO during calendar year 1999 in accordance with the limits set forth below. The limit established for each state takes into account various factors including: the catch of national fleets during the period 1985-1998; the amount of catch historically taken within the zones where each state exercises sovereignty or national jurisdiction; the landings of tuna in each nation; the contribution of each state to the IATTC conservation programme; including the reduction of dolphin mortality; and other factors.

| | Carrying capacity (metric tonnes) |
|---|---|
| Belize | 1 877 |
| Colombia | 6 608 |
| Costa Rica | 6 000 |
| Ecuador | 32 203 |
| El Salvador | 1 700 |
| Honduras | 499 |
| Mexico | 49 500 |
| Nicaragua | 2 000 |
| Panama | 3 500 |
| Spain | 7 885 |
| United States | 8 969 |
| Vanuatu | 12 121 |
| Venezuela | 25 975 |

2. The capacity levels established above shall not apply to a limit of 32 United States vessels authorized and licensed to fish in other areas of the Pacific Ocean under an alternative international fisheries management regime, and that may occasionally fish to the east of 150 degrees west longitude, provided that: a) the fishing activity of any such vessels in the EPO is limited to a single trip not to exceed 90 days in one calendar year; b) the vessels do not possess a Dolphin Mortality Limit; and c) the vessels carry an approved observer. A similar exception shall be considered for vessels from other countries with a similar record of participation in the EPO tuna purse-seine fishery and that meet the criteria listed above.

3. The High Contracting Parties also acknowledge and affirm the right of several states without vessels currently fishing in the EPO, but with a longstanding and significant interest in the EPO tuna fishery, to develop their own tuna fishing industries. They further acknowledge that, in accordance with their legitimate rights under international law, several EPO coastal states, including France and Guatemala, have expressed an immediate interest in developing their own tuna fishing fleet in the EPO.

4. Other states, including Colombia, El Salvador, Nicaragua, Panama, and Peru, have expressed their interest in increasing the carrying capacity of their fleets licensed to fish for tuna in the EPO.

5. Any state listed in Paragraph 3 seeking to enter the fishery through the development of its own fishing fleet in the EPO shall not be bound to a national capacity level for calendar year 1999. Should the actual fishing capacity for new entrants approach 6 000 tonnes, the Commission would meet to consider immediate action in accordance with paragraph 6, below. Further decisions on establishing national capacity limits for any state that brings a new vessel or vessels into the fishery shall take into account the criteria established in paragraph 1 above and the state's right under international law.

6. The High Contracting Parties agree to review annually the level of actual fishing capacity in the EPO. The Parties agree to consider measures to ensure that fishing capacity corresponds to the level of fishing capacity described in paragraph I above. At such time as the actual level of fishing capacity approaches a level where the sustainability of the fisheries is of concern, the Parties agree to meet to consider immediate action to adjust capacity or to take other action to ensure the sustainability of the fisheries.

*The High Contracting Parties agree* to establish a permanent working group to review, on an annual basis, the capacity of the tuna purse seine fleet in the EPO and formulate additional recommendations for the consideration of the Commission.

# INDIAN EXPERIENCE ON ASSESSMENT, MEASUREMENT AND MONITORING OF FISHERY RESOURCES AND FISHING CAPACITY

**V.S. Somvanshi**[1]

**Abstract:** The Maximum Sustainable Yield (MSY) of the fish stocks is assessed through exploratory surveys conducted in the Indian EEZ. This potential yield estimate provided the basis for development of fisheries including both traditional and modern fishing sectors in coastal and deep sea regions respectively. The Indian fisheries were exploited by small-scale fishermen until the 1950s. The introduction of trawling and a purse seining on large-scale during the second half of the twentieth century enabled India to increase the marine fish production to 2.9 million tonnes.

The present fleet strength of 228 758 fishing crafts consists of traditional craft (66 percent), motorized traditional crafts (17 percent) and mechanized boats (17 percent). The factors affecting the number and capacity of the fleet over the last two decades have been the magnitude of fish stocks, and fishing power of the vessels, profitability of each type of fleet and, in certain cases, the size of fishing gear. The fleet owners have diversified their fishing methods, with shrimpers and stern trawlers now fishing in the distant waters on resources such as deep sea demersals and tuna and allied fishes. There is also scope for diversification, especially for the shrimp trawlers, through shift fishing effort in the existing fishing grounds on to non-shrimp resources such as mackerel which are abundant on the same ground.

The indigenous fishing capacity is also reflected in the increased marine fish production over the years. India practices stratified random sample techniques in relation to space and time to collect and monitor the catches, landed by the indigenous fleet. The time series data on fish landing thus collected has enabled the assessment of the fish production and helped determining the optimum fleet size for each type of fishing crafts. There has been consensus on maintaining certain fishing fleet strength at the present level. In the case of deep sea fishing for demersal, midwater/pelagic and oceanic fish stocks, there is a need to upgrade the fishing capacity of larger crafts and introduce new generation vessels for tapping these resources.

## 1. INTRODUCTION

India is one of the coastal nations that witnessed rapid development of marine fisheries in the post-EEZ era. As attendant responsibilities of a coastal State, India has been conducting exploratory surveys in the EEZ in order to determine the types of fish resources and their potential. Following the results of these surveys, there has been a renewed vigour in the introduction of new technologies and fishing methods in commercial sectors, and modernization of artisanal craft and fishing techniques. This provided impetus for horizontal and vertical expansion of fishing capacity. However the expansion of fishing areas has not been commensurate with the increase in capacity. The impact of this situation often manifests in the form of fluctuations in the coastal pelagic fish production. Nevertheless, India has made significant increases in marine fish production, achieving the seventh position among the fish producing nations of the world.

## 2. PRODUCTIVITY AND PRODUCTION

### 2.1 Maximum Sustainable Yield

During the 1950s, India's marine fishing was mainly exploited by artisanal fishermen as fisheries aimed at subsistence. Commercial fishing activities were also developed by introducing trawling and purse seining techniques. Intensive and extensive surveys were also

[1] Fishery Survey of India, Botawala Chambers, Sir P.M. Road, Mumbai – 400 001.

undertaken to provide necessary estimates on the potential of fish stocks, and the findings of these surveys led to the recommendation of a development programme emphasizing mechanization of suitable indigenous crafts during the second half of the current century.

Fishery Survey of India, (FSI) an agency of the Government of India, has been responsible for surveys and assessment of the marine fishery potential of the Indian EEZ. The Maximum Sustainable Yield (MSY) of the fish stocks from the Indian EEZ has been assessed as 3.9 million tonnes, which includes the demersal (1.93 million tonnes), pelagics (1.74 million tonnes) and oceanic (0.25 million tonnes) resources (Sudarsan *et al.,* 1990). In contrast, the present marine fish production is only 2.9 million tonnes. The coastal zone (up to 50m depth), which holds an estimated potential production of 2.28 million tonnes, is experiencing fishing pressure by the operation of traditional and mechanized boats. The details of maximum sustainable yield and exploitation level of the resources in relation to depth zones are presented in Table 1.

*Table 1. Maximum Sustainable Yield level of exploitation and the depth wise potential available for exploitation within the Indian EEZ (in million tonnes)*

| | Depth range (m) | | | | |
|---|---|---|---|---|---|
| | 0-50 | 50-200 | 200-500 | Oceanic | Total |
| Demersal | 1.28 | 0.625 | 0.028 | - | 1 933 |
| Neretic pelagic | 1.00 | 0.742 | - | - | 1 742 |
| Oceanic pelagic | - | - | - | 0.248 | 0.248 |
| Total | 2.28 | 1 367 | 0.028 | 0.246 | 3 921 |
| | (58%) | (35%) | (0.7%) | (6.3%) | - |
| Level of exploitation | 2.08 | 0.63 | Negligible | Negligible | 2.71 |
| Available for exploitation | 0.2 | 0.737 | 0.028 | 0.246 | 1 211 |

## 2.2 Marine fish production

The marine fish production registered a steady increase from 0.85 million tonnes in 1960 to 2.94 million tonnes in 1996 (Table 2). Motorization of the traditional crafts, introduction of mechanized boats in the traditional sector, diversification of fishing effort beyond 50 m depth, incorporation of new fishing technologies and development of purse-seining operation have resulted in the enhancement of the fish production over the years. The pelagic fisheries, such as oil sardine and mackerel fisheries, exhibit year-to-year fluctuations (Madhupratap *et al,.* 1994), mainly due to the oceanographic parameters.

*Table 2. Marine fish production (million tonnes)*

| Year | Production |
|---|---|
| 1960 | 0.88 |
| 1970 | 1.09 |
| 1980 | 1.55 |
| 1990 | 2.26 |
| 1996 | 2.94 |

Source: MOA, 1996; FAO, 1999.

## 3. INDIA'S FISHING CAPACITY

### 3.1 Growth and changes in the fishing capacity: Fleet types and strength

There are several major categories of fishing fleets that operate in the coastal inshore and offshore waters. These are the non-motorized traditional craft, motorized traditional craft and mechanized boats, the latter of which include trawlers, purse-seiners, gillnetters and longliners. The decades up to the seventies were mostly dominated by the traditional craft. However, motorization of traditional crafts and introduction of mechanized boats brought about rapid changes in the exploitation of the inshore and offshore resources, achieving remarkable increases in production. The present fleet strength of the different categories of boats is 228 758 (Table 3),[2] of which 190 857 are traditional craft (both non-motorized and motorized) and 37 901 mechanized boats (Devaraj, 1998).

*Table 3. Changes in the types and number of craft, 1985-1995*

| Fleet | 1985 | 1995 |
|---|---|---|
| Traditional | 168 891 | 190 857 |
| • Non-motorized | 161 963 | 151 554 |
| • Motorized | 6 928 | 39 303 |
| Mechanized | 26 733 | 37 901 |
| • Trawlers | 16 189 | 24 099 |
| • Purse-seiners | 578 | 464 |
| • Others | 9 966 | 13 338 |

In 1985, non-motorized traditional crafts constituted 96 percent of the total traditional crafts while motorized crafts were only four percent (Table 3). In 1995, the percentage of non-motorized crafts was reduced to 79 percent, with an increase of 21 percent in motorized craft. Similarly, there was a corresponding increase in the number of mechanized boats from 46 percent in 1985 to 54 percent in 1995. The twin initiatives of shifting a number of crafts from non-motorized to motorization and increase in the introduction of mechanized boats resulted an increase in the fishing capacity by extending the areas of operation well beyond the 50 m depth zone and up to 150 m depth. The areas below 50 m depth (corresponding to 12 nautical miles distance from the shore) have been left exclusively for the traditional and small mechanized sectors through the legislation. The initiative of organizing workshops and effort to create awareness among the fishers and fleet owners regarding deep sea resources, diversified techniques and use of electronic fish finding, navigation and communication equipment have been helping in bridging the gap between the expansion of fishing capacity and the limitations of the traditional fishing areas, with greater emphasis placed on encouraging deep sea fishing.

### 3.2 Capacity diversification

The magnitude of fish stocks and fishing power compared with the scale of profit of each type of fleet, and in certain cases the size of fishing gear, are the determining factors in limiting fishing capacity. In order to ease out the fishing pressure in specific areas as well as on some resources like shrimps, fleet owners have been encouraged to undertake diversified fishing by suitably converting their vessels. Free training is offered in specialized fishing for

[2] The records of the Ministry of Agriculture indicate a total fleet size of 238 125 fishing boats (MOA, 1996), although some of these can not be classified.

deep sea shrimp and lobsters, tuna longlining, etc., as an incentive to undertake diversification. The effort made by the Indian Government in establishing the deep sea fishing development during the past two decades by encouraging the fishers to undertake deep sea fishing has been a positive action towards sustainable development of the fisheries. At present, there are about 80 deep sea fishing vessels in operation. Some of these are being suitably modified to shift their fishing activity onto non-shrimp resources. A number of these shrimpers have also been converted to multipurpose fishing activities (Somvanshi, 1999), diversifying operation by migrating from shrimp grounds on the east coast to west coast for harvesting squids and cuttlefishes, deep sea shrimps and lobsters (MOA, 1996, MPEDA, 1996).

The application of advanced technology to increase marine productivity of outer shelf and high seas is yet to be undertaken, as it requires huge investment. Management measures such as controlling fishing effort through catch quota system or TACs is difficult in the open access system. A strict control of a number of fishing licences and fishing power of individual vessels will be useful and effective in the management of the resources.

### 3.3 Capacity for oceanic tuna fishing

The deep sea fishing schemes are expected to result in further increases in fish production from the oceanic region in the Indian EEZ. The schemes aim to familiarize the Indian fishers in oceanic fishing enterprises and skills. These schemes pertain to the charter of fishing vessels (1981) and joint venture and leasing foreign vessels (1991). The schemes implemented during the eighties and nineties provided necessary inputs in achieving these objectives. In 1990, the Indian Ocean tuna production reached a peak of 12 572 tonnes (Somvanshi and John, 1996). The details of the fishing fleet mainly tuna longliners and catches are given in Table 4.

*Table 4. Oceanic tuna fishing capacity*

| Year | No. of vessels | Catch (t) | GRT of chartered tuna longliners | | | |
|---|---|---|---|---|---|---|
| | | | 200-400 | 400-600 | 600-800 | 800-1000 |
| 1985 | 1 | 7 | 1 | - | - | - |
| 1986 | 10 | 1 953 | 1 | 9 | - | - |
| 1987 | 5 | 906 | 1 | 3 | 1 | - |
| 1988 | 8 | 947 | 2 | 4 | 2 | - |
| 1989 | 30 | 3 986 | 2 | 13 | 15 | - |
| 1990 | 58 | 12 572 | - | 13 | 45 | - |
| 1991 | 22 | 5 198 | 1 | 2 | 19 | - |
| 1992 | 23 | 5 671 | 2 | 6 | 15 | - |
| 1993 | 28 | 2 768 | 3 | 7 | 18 | - |
| 1994 | 17 | 2 579 | 2 | 7 | 5 | 3 |

Some of the Indian fishers also acquired tuna longliners and contributed to the production of tuna and allied fishes, albeit in small quantities. The charter scheme was replaced in 1991 with schemes encouraging joint venture and leasing of foreign fishing vessels. Nevertheless, these schemes could not match the charter capacity, thereby creating a decline in the capacity for oceanic tuna resources exploitation. The exploratory survey results and the operation of chartered vessels have shown and proved that the Indian EEZ has considerable potential for tunas (0.25 million tonnes). India has therefore greater scope to build up oceanic resource fishing capacity in the new millennium.

## 3.4 Assessment of optimum fleet strength

The marine fishing capacity in the form of traditional motorized and mechanized boats is being assessed at institutional level. In one such exercise, the optimum fleet for different categories of crafts (CMFRI, 1998) was estimated (Table 5).

This is the first ever attempt to consider all the types of fleet for determining their optimum sizes. However, the optimum fleet size has to be linked with specific fisheries and the extent of distributional range of the fish stocks and the effective fishing zone. Another important aspect to be considered, along with environmental parameters which will have relevance to determine the fishing fleet strength, is the fact that the tropical conditions in which the majority of the stocks are prolific breeders and that the fisheries operate on zero to two year class strength of the fishes. The new millennium should focus on these aspects, undertaking necessary R&D activities and linking them with fleet strength and management measures need to be applied in the fishing practices in the seas around India.

*Table 5. Estimated optimum fleet size*

| Fleet segment | Number of vessels |
|---|---|
| Mechanized | 15 998 |
| • Mechanized trawlers | 12 245 |
| • Purse seiners | 835 |
| • Mechanized gillnetters | 3 972 |
| • Mechanized bagnetters | 2 193 |
| • Other mechanized boats | 1 683 |
| | |
| Motorized | 2 0928 |
| • Outboard bagnets | 326 |
| • Outboard gillnetters | 10 746 |
| • Outboard ring-seiners | 1 302 |
| • Outboard dol-neters | 159 |
| • Outboard other boats | 3 465 |
| | |
| Non-mechanized | 31 058 |
| | |
| Total | 67 984 |

## 4. MONITORING AND MANAGEMENT

The Ministry of Agriculture is the agency that collects, collates and monitors the fish catches and fishing fleets through the provincial governments, fisheries departments and the central institutions like Central Marine Fisheries Research Institute (CMFRI) and Fishery Survey of India (FSI). A stratified random sampling involving the clusters of the landing centres and days for enumeration developed by the CMFRI is used for collecting catch and effort data and other relevant information. Information on the fishing crafts and gear is collected through a census by the central and state agencies, which are updated from time to time. At the national level, capacity limitation in certain fisheries was exercised by imposing bans. For example, in the shrimp fishery, acquiring outrigger shrimp trawlers during the eighties was prohibited.

The Marine Fisheries Regulation Act (MFRA) by the maritime provincial government and the deep sea fishing schemes, as provided under the Maritime Zones of India (operation of foreign fishing vessels) Act 1981 of the Government of India, provide for prohibition of fishing by larger vessels in the areas earmarked for the traditional and small motorized crafts, shrimp and lobster grounds, and marine reserves/parks. Also, these Acts allow the imposition of bans on fishing during the monsoon season, thereby providing respite to the brooders and ensuring recruitment to the stocks. There have been also mesh size regulations provided under the provincial Acts and national legislation with reference to the specific gears and use of explosives and dynamites is prohibited. For monitoring the fishing activities to be carried out in different assigned fishing zones by respective fleets, petrol boats are provided to the fisheries department of the maritime States. The resources monitoring surveys conducted by the FSI are being linked with the management measures to be evolved and applied for sustainable development of fisheries.

## 5. CONCLUSION

India has registered a rapid developmental phase in marine fisheries during the second half of the twentieth century, achieving a current annual marine fish production of 2.94 million tonnes from the Indian EEZ. Mechanization of the indigenous crafts, introduction of commercial fishing techniques, and launching of deep sea fishing schemes were the main factors responsible for achieving the present level of fishing capacity and fish production.

The industry also experienced upheaval during the mid-eighties due to over-dependence on large trawlers in the North East Coast on shrimp stocks. Nevertheless, the experience triggered the acceptance of diversified fishing by the fishers for non-shrimp resources and catalyzed the idea of shifting fishing activity in the same region and transferring effort to distant areas. In the small and medium mechanized sectors, diversification from stern trawling operation to purse seining and longlining was found acceptable to the fishers. Thus, the fishing capacity is still within the range of sustainable fisheries considering the distributional expanse and potential of fish stocks in the Indian EEZ. However, there is consensus at National level that the strength of the mechanized fleet should be maintained at the present level. The efforts are on for providing modern electronic equipments such as echosounders, fishfinders, GPS and communication equipment etc. to the larger boats among the mechanized fleet so that these boats will be able to undertake fishing in distant and deeper waters for the deep sea and oceanic resources identified and their magnitude determined through the exploratory surveys.

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# FISHING CAPACITY AND FISHERIES IN PAKISTAN

**Muhammad Hayat**[1]

**Abstract:** Fishing is the most important economic activity in the coastal area of Pakistan, contributing to employment, income generation and export revenues. Marine production has increased more than ten-fold while inland production has increased more than twenty-fold over the last 50 years, largely as a result of government assistance. As a result of this production increase, the resource of key species (particularly shrimp) has been severely depleted in the coastal waters. Concentration of activity in the coastal waters has resulted in the area between 12-35 nautical miles being under-utilized due to the lack of modern boats with the equipment necessary to exploit these areas. Measures introduced to reduce the coastal water overexploitation include seasonal closures, reduction in boat numbers and encouraging diversification of activity into the less exploited fisheries.

## 1. INTRODUCTION

The fisheries sector in Pakistan makes a significant contribution to the national economy, contributing about one percent to GDP and providing jobs to about one percent of the country's labour force. It is the most important economic activity in the coastal area of Pakistan. It is estimated that 400 000 fishermen and their families are dependent on the fisheries sector for their livelihood. Its contribution to the country's export earnings is quite substantial. About 83 000 million tonnes of fish and fishery products valued at Rs. 7.27 billion (US$ 172 million) were exported in 1997.

The Government is taking an interest in the development of the fisheries sector of Pakistan. Emphasis is being given to strengthening the fisheries infrastructure, enhancement of fish production, increase in export earnings as well as domestic consumption of fish, diversification of fishing effort, exploitation of hitherto untapped resources and, above all, improving the socio-economic condition of the fishing communities. Because of these efforts, fish production has increased to a level of 615 904 tonnes in 1998, with 433 098 tonnes from marine and 182 806 tonnes from inland bodies (Table 1).

*Table 1. Marine fish production of Pakistan (in m. tonnes)*

| Year | Marine | | | | Inland | Total |
|---|---|---|---|---|---|---|
| | Sindh | Balochistan | EEZ | Total Marine | | Production |
| 1947 | 23 910 | 8 983 | - | 32 893 | 7 050 | 39 943 |
| 1950 | 26 360 | 10 889 | - | 37 249 | 10 400 | 47 649 |
| 1960 | 45 824 | 16 333 | - | 62 157 | 18 500 | 80 657 |
| 1970 | 102 418 | 37 385 | - | 139 803 | 18 740 | 158 543 |
| 1980 | 175 255 | 57 688 | - | 232 943 | 46 320 | 279 263 |
| 1990 | 260 246 | 107 226 | 2 330 | 369802 | 113 158 | 484 960 |
| 1998 | 295 648 | 130 799 | 6 651 | 433 098 | 182 806 | 615 904 |

Fishing in the past was predominantly concentrated on shallow water coastal stocks. Trawling for shrimp was the main commercial fishing activity. Because of uncontrolled increases in the shrimping fleet, its resources have severely been depleted and there is a general fear that these fisheries, which are the main stay of our exports from Pakistan, may collapse in the near future. Considering this, some management measures for the conservation of our shrimp stock, as suggested by fishery biologists, are as being taken such as (i) imposing

[1] Assistant Fisheries Development Commissioner, Ministry of Food, Agriculture and Livestock, Government of Pakistan, Islamabad, Pakistan.

a two months ban on shrimping during May-June; (ii) reduction in number of trawlers; and (iii) diversification of fishing efforts. Gillnetting and longlining in comparatively deeper water is recommended for diversification of shrimp trawlers. This diversification has picked up pace. It is estimated that at least 300 shrimp trawlers have been converted into gillnetters and longliners. At present, about 18 000 boats are involved in fishing in the coastal waters of Sindh and Balochistan.

## 2. GEO-PHYSICAL FEATURES OF FISHING AREA

Pakistan is endowed with rich fishing potential. It is located in the northern part of the Arabian Sea. The Arabian Sea at the coast of Sindh and Balochistan has rich fish deposits of commercial importance. Pakistan has a coastline of about 1 120 km, with a number of bays and broad continental shelf lying in front of the Indus deltas which are ideal for growth of marine life. The Exclusive Economic Zone of Pakistan extends up to 200 nautical miles from the coast. Major fish centres are Karachi, Gwadar and Pasni. Most of the marine catch is done within 12 nautical miles. On the basis of topographical features and productivity, the coast is divided into two zones, i.e. the northwestern region or Makran coast, and the southeastern region or Sindh coast

The northwestern region (or Mekran Coast) extends from Hub River to the Iranian border, which is about 772 km long. The entire shelf area of this region comes to about 14 530 km$^2$. The bottom is generally rock and the shelf is uneven. The continental slope (i.e. isobath of 200 m) starts between ten and 30 miles along the coastline. The region is characterized by a number of bays such as Sonmiani, Ormara, Kalmat, Pasni, Gwadar and Gwater bays. Trawling is possible in some areas but in most part, the shelf is narrow and has rough bottom and beset with numerous rugged canyons and rocky areas.

The southeastern region (or Sindh Coast) is 348 km long and extends between the Pakistan-Indian border and the Hub River. The bottom is generally sandy or sandy-muddy. The shelf area is about 35 740 km$^2$. The shelf in most areas in the Indus delta region extends up to 80 miles. The region, unlike Balochistan, is characterized by a network of creeks having mangroves that serve as a nursery ground for finfish and shellfish resources.

## 3. EXISTING FISHERIES RESOURCES

Various governments, FAO and other UN agencies, and the Marine Fisheries Department of the Government of Pakistan have undertaken independent studies to determine the size of the fishery resources in Pakistan, but have all arrived at different estimates. The estimates of biomass, maximum sustainable yield, landing and incremental potential (i.e. the additional output that could be achieved) for different species of fish derived by the Marine Fisheries Department are given in Table 2.

From Table 2, it can be seen that shrimp, cephalopods, molluscs, crabs and lobsters do not have much incremental potential after the landings were deducted from MSY. Therefore, the only additional benefit to be derived from these species is to have value added processing. Considerable incremental potential exists in small pelagic species such as sardines and anchovies, and in large pelagic species such as tuna and mackerel. These species can be used for canning and other forms of processing of sardines, anchovies and tuna. Tuna and mackerel can also be processed raw (sashimi) and loin (frozen). The largest incremental potential (about 5 million tonnes) is for mesopelagic lantern fish. These fish are 2.5-5 cm long, and are found between 300-1 000 meters depth during the day, and between 50-500 meters during the night. These, however, are only good for making fish meal, preferably on board.

*Table 2. Fish resources and incremental potential (tonnes)*

| Resources | Biomass | M.S.Y. | Landings (1996) | Incremental potential |
|---|---|---|---|---|
| Small pelagic species | 700 000 | 300 000 | 98 500 | 200 000 |
| Large pelagic species | 80 000 | 60 000 | 33 600 | 26 000 |
| Demersal species | 500 000 | 300 000 | 225 600 | 74 300 |
| Shrimp | 88 000 | 35 000 | 27 800 | - |
| Cephalopods | 20 000 | 12 000 | 5 900 | 6 000 |
| Molluscs | 8 000 | 4 000 | 5 000 | 3 500 |
| Crabs | 10 000 | 6 000 | 3 200 | 2 800 |
| Lobster | 1 300 | 6 000 | 7 000 | - |
| Mesopelagics | 10 000 000 | 5 000 000 | - | 5 000 000 |
| Total | 11 407 300 | 5 717 600 | 395 800 | 5 312 300 |

Most of the marine catch is taken within 12 nautical miles from the coast as the boats are small with little catching and preserving equipment on board. This reduces the catch per boat and, therefore, increases the cost of fish per kg. The area from 12-35 nautical miles (Zone-I), although reserved for local fishermen, remains under-utilized as a consequence of the paucity of modern boats equipped with the equipment necessary for catch and preservation in this area.

## 4. INSTITUTIONAL FRAMEWORK

Fishing within territorial waters (up to 12 nautical miles) is basically a provincial responsibility. All the four provinces of Pakistan, namely Punjab, Sindh, NWFP and Balochistan have Departments of Fisheries and each Department has a Directorate under it to deal with the subject of fisheries. The basic role of provincial governments is the implementation of work in the fishery sector, and the operation of fish harbours under their jurisdiction. Inland fishing and fish farming is also under the control of provincial governments, which supply seed, run hatcheries, provide extension services, collect primary data and promote fisheries through producing literature and brochures and running seminars.

Fishing beyond territorial waters (which includes the deep sea activity) is however, a federal responsibility. The federal Ministry of Food, Agriculture and Livestock is the principal ministry dealing with the fishery sector. It primarily deals with policy making regarding fish catching, exporting, and the future development of the sector. It also obtains loans from foreign sources such as the Asian Development Bank and foreign governments. The Ministry is also responsible for the collation of data collected by the provinces at the national level. It also controls the issuance of licences to fish processing units for exporting processed fish, and to vessel operators for operating ships in deep-sea waters. It also plays a role in the operation of projects such as Korangi Fish Harbour. The federal Ministry of Communications controls and operates Gwader Fish Harbour, Balochistan.

In addition to the role of government, cooperative societies also play an important role in the organizing and running of the fisheries. There are a number of cooperative societies, primarily in the harbour areas. Fishermen's Cooperative Society of Karachi, Balochistan Fishermen's Cooperative Society of Gwadar, Fishermen's Association of Mekran, and Anjuman Ittehad-e-Mahigiran (Association of United Fishermen) in Balochistan are the major cooperative societies. The societies provide a united platform to the fishermen for dealing with government and other agencies, to protect and fight for the causes of fishermen, to help them in marketing to provide nets and other items, etc. Other cooperative societies also work on the same basis but on a much smaller scale.

## 5. FISHING BOATS AND FISHING OPERATIONS

Most of the fishing boats being used in Pakistan are made of wood. There are about 19 000 registered boats in Pakistan, of which about 14 000 boats are being operated from Sindh, and the remaining 5 000 fishing boats being operated from Balochistan. In the Exclusive Economic Zone of Pakistan, 30 fishing vessels (20 stern trawlers and 10 tuna longliners) are permitted by the government to operate beyond 35 miles from the coastline. Fishing activities are continued throughout the year; however, peak fishing seasons are during post-southwest monsoon calm period (September to November). Shrimp are caught throughout the year except June and July, during which time the Government of Sindh imposes a closed season.

The most common fishing gear used in Pakistan is the gillnet, used by both small as well as larger fishing vessels. Smaller fishing boats employ gillnets in shallow waters, and catch a variety of demersal fishes such as croakers, pomfrets, trevallies, mullets, catfishes and sharks. Bottom set gillnets, locally known as tukri, are also used for catching shrimp. In contrast, trawling for shrimp is the most important fishing gear being used in Pakistan, and is undertaken by medium sized fishing trawlers (LOA 15 to 20 m). Large gillnetters are employed for catching tuna, mackerel, sailfish and other pelagic species in offshore waters. Sardinellas and anchovies are caught in shallow coastal waters using encircling nets locally known as katra. Line gears are also used in shallow coastal waters for catching seabreams, croakers, eels and other demersal species.

Fishing is undertaken right from the seashore to 200 nautical miles out to sea. This distance has been divided into two broad categories known as (i) coastal water fishing (up to 12 nautical miles) and (ii) deep sea fishing. The area of deep sea fishing has further been divided into Zone-I (12 to 35 nautical miles) and Zone-II (35 to 200 nautical miles). Coastal water fishing is undertaken in most coast villages. These villages are predominantly inhabited by fishers whose main livelihood is fishing. In contrast, deep-sea fishing in Zone II is undertaken largely as a commercial venture. The zone is reserved for foreign as well as Pakistan Flag vessels. Several restrictions are imposed on the fleet operating in this zone, including:

- A royalty of US$5 000 per fishing trip is charged from bottom/ midwater trawlers and squid jigging vessels, in advance, prior to the issuance of N.O.C. for each fishing trip. A fishing trip is limited to 60 days, however it terminates when a vessel reports at the port for offloading of the fish catch.
- Licensees are entitled to determine the mode of procurement of vessels, either on a self-ownership basis or on a charter/joint venture basis. Licensees are not given licences for more than two vessels.
- The licensee is not permitted to trans-ship the fish catch at sea. Vessels are encouraged to land/export their catch from Korangi Fisheries Harbour. However, when it is technically possible the vessels will be bound to land/export the catch from Korangi Fisheries Harbouronly. A US$40 commission is charged by the Korangi Fish Harbour

Authority to vessels offloading their catch at the Korangi Fisheries Harbour, and US$2 000 on every offloading/trans-shipment elsewhere.

- All vessels have to employ at least 25 percent Pakistani crew, and arrange for their training on board.

## 6. FISH PRODUCTION AND EXPORT

Pakistan is rich in marine fishery resources, where catching is done in the coastal areas of Sindh and Balochistan. The catch consists of more than 30 species of shrimp, ten species of crab, five species of lobster, and 70 commercial species of fish including sardine, hilsa, shark, mackerel, butter fish, pomfret, sole, tuna, seabream, Jew fish, catfish and eel. In 1998, almost 40 000 tonnes of shellfish were harvested from coastal waters of Pakistan (Table 3). Shellfish such as shrimp, lobsters and crabs are also important export species. In addition to domestic consumption, about 73 000 tonnes, valued at Rs. 0.6 billion, of fish and fishery products are exported mainly to China, Japan, European Union and Persian Gulf countries (Table 4).

*Table 3. Shellfish production in Pakistan (in t)*

| Species | Balochistan | Sindh | EEZ | Total |
|---|---|---|---|---|
| *Shrimp (total)* | 835 | 25 369 | - | 26 204 |
| • White shrimp | - | 5 311 | - | 5 311 |
| • Pink/brown shrimp | - | 6 204 | - | 6 204 |
| • Kiddi shrimp | - | 13 854 | - | 13 854 |
| • Misc. shrimp | 835 | - | - | 835 |
| Lobsters | 481 | 301 | - | 782 |
| Crabs | - | 5 680 | - | 5 680 |
| Cephalopods | 18 | 6 325 | 182 | 6 525 |
| *Total shellfish* | 1 334 | 37 675 | 182 | 39 191 |

*Table 4. Fish export (1998)*

| Commodity | Quantity (m. tonnes) | Value (000 Rs) |
|---|---|---|
| *Fish* | 46 063 | 1 974 694 |
| • Salted | 18 610 | 548 775 |
| • Frozen | 24 249 | 1 220 126 |
| • Chilled | 3 168 | 203 905 |
| • Others | 36 | 1 888 |
| *Shrimp* | 15 921 | 3 209 779 |
| • Frozen | 15 900 | 3 208 037 |
| • Others | 21 | 1 742 |
| *Lobsters* | 104 | 38 113 |
| • Frozen | 79 | 29 624 |
| • Live | 25 | 8 489 |
| *Crabs* | 4 078 | 194 121 |
| • Frozen | 97 | 25 471 |
| • Live | 3 940 | 165 385 |
| • Canned | 41 | 3 265 |
| *Molluscs* | 5 806 | 335 213 |
| • Frozen | 5 674 | 331 456 |
| • Preserved | 132 | 3 757 |
| *Fish products* | 1 738 | 182 615 |
| • Fishmeal | 1 568 | 22 535 |
| • Fish maws | 92 | 86 163 |
| • Shark fins | 78 | 73 917 |
| *Total* | 73 710 | 5 934 535 |

## 7. FUTURE DEVELOPMENTAL STRATEGY

The area between 12-35 nautical miles, although reserved for local fishermen, remains under-utilized due to the lack of modern boats equipped with necessary equipment for catch and preservation. The area between 35-200 nautical miles which is declared as EEZ Zone II is reserved for foreign as well as Pakistan Flag vessels which operate under licence from the Government of Pakistan. The catch in Zone II is very nominal and, therefore, has potential for increased exploitation.

The immediate need in the shrimp fishery is to enforce measures that will stop overfishing due to too many trawlers. This will allow the stocks of “Jaira” and “Kalri” shrimp to recover and production to rise. These measures should also minimize the danger of depletion of shrimp stocks (including “Kiddi”) through overexploitation. Overfishing has reduced the proportion of shrimp in total fish exports in value and volume terms. Shrimp aquaculture along creeks and shallow waters near the coast has to be developed. Fish processors are apprehensive of the future prospects of shrimp catch because of pollution hazards, decreasing discharge of the Indus River due to construction of dams and barrages, and overexploitation.

The unexploited available yield of demersal species is estimated to be 74 000 tonnes a year. Most of this is located in the portion of the continental shelf beyond the 20 m depth line. Financial and other assistance should be provided to surplus shrimp trawlers to convert to gillnetting, longlining or other techniques for exploiting under-utilized demersal stocks. Bottom gillnetting can yield substantial amount of untapped shark, bream, catfish, grunts and sweet lips, cracker, snapper and grouper similarly longlining can yield shark and other fish.

The potential also exists for catching pelagics such as tuna, mackerel and shark. Cuttlefish and squid resources exist on the continental shelf and oceanic squid beyond the shelf. Good development possibilities exist for cephalopod fishing, which is almost non-existent so far.

A large amount of mesopelagic resources remain unexploited and an annual catch of several hundred thousand tonnes can be expected. Other potentially exploitable resources exist including mussels, oysters, clams, crabs, algae, sea urchins, etc. Further investigations should be made to determine the feasibility of developing fisheries or mariculture farms and pilot projects should be formulated, where appropriate, to encourage the private sector.

Efforts have to be made to exploit the commercial possibilities of alternate fisheries. These include seaweeds, crustaceans (other than shrimp), molluscs, and echinodrum.

# MONITORING, MEASUREMENT AND ASSESSMENT OF FISHING CAPACITY - THE MALAYSIAN EXPERIENCE

**Mohd Taupek and Mohd Nasir**[1]

**Abstract:** This paper provides a brief history of the evolution of the Malaysian fishery as a whole and illustrates the real situation of the fishery from its humble beginning before the introduction of trawlers in the early 1960s to the present overexploited condition of the fish resources in the 1990s. It outlines the different known problems besetting the fishery and also deals with the various management measures and monitoring systems undertaken by the Department of Fisheries Malaysia to rectify the situation arising from excessive fishing capacity and the estimated limited success from the implementation of such measures. Fish resource surveys undertaken at regular intervals helped to establish the status of the fish resources within specific areas, and these were further supplemented by various analyses (mostly through the use of 'surplus production models') on data obtained from direct research, commercial vessels and annual fisheries statistics. The alarming state of resource degradation which most of the marine waters in Malaysia are experiencing at present provides clear indication that a more effective management approach is vitally needed to remedy such imbalances in the performance of the fishery.

## 1. INTRODUCTION

The issues of excessive fishing capacity and resource overexploitation have been raised well within the past decade in reference to growing concern about the spreading phenomenon of excessive fishing inputs and valuable stocks depletion in world fisheries, and more so with fisheries that lie in the tropics. The two issues are in most cases inter-related, the first due essentially to having too many vessels or excessive harvesting power, and the second due to the general degradation of fishery resources usually from the manifestation of the first factor, in a growing number of fisheries. This undesirable situation, if left unchecked, could inevitably lead to other serious ramifications, notably that of a general dampening of the economic activities within the fishery sector of the countries concerned and thereby affecting whole societies that are directly or indirectly dependent on this sector. Prices of fish commodities would generally increase, which is counter to the objective of promoting fish as a relatively cheap source of protein to most people. In all cases, the management strategies applied to regulate these fisheries would normally come under scrutiny.

## 2. BACKGROUND

### 2.1 Geographical location

Malaysia lies in the tropics (Latitudes 1- 8 $^{o}$N, Longitudes 100-119 $^{o}$E), and comprises Peninsular Malaysia and the states of Sabah and Sarawak (Figure 1). Peninsular Malaysia, as the name suggests, is bounded by the sea on most of her sides, except in the north, where she is attached to mainland Asia via the Isthmus of Kra of Thailand. The island of Borneo located 1 200 km to the east of the Peninsular across the blue South China Sea, houses another two Malaysian states: Sabah and Sarawak (or East Malaysia). Sabah occupies the northern part of Borneo, while Sarawak is located entirely on the west of the island.

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[1] Marine Fishery Resources Development and Management Department, Department of Fisheries Malaysia, Chendering, 21080 Kuala Terengganu, Malaysia. The authors would like to express their deep appreciation to the Director-General of Fisheries Malaysia and the Chief of SEAFDEC MFRDMD for providing the opportunity to present this paper. Financial support to attend this meeting was kindly provided by the FAO.

The west coast of the Peninsular is bordered mainly by the Straits of Malacca, and some portion of the Andaman Sea up north, and the Java Sea down south. The east coast of Peninsular Malaysia, however, faces the South China Sea, as with Sarawak, and the western part of Sabah (Figure 1). The waters here mostly lies on a continental shelf that is largely comprised of sandy bottom substrates and is generally shallow (<100 m in depth), but in some parts of western Sabah, water depth can extend to more than 2 000 m.

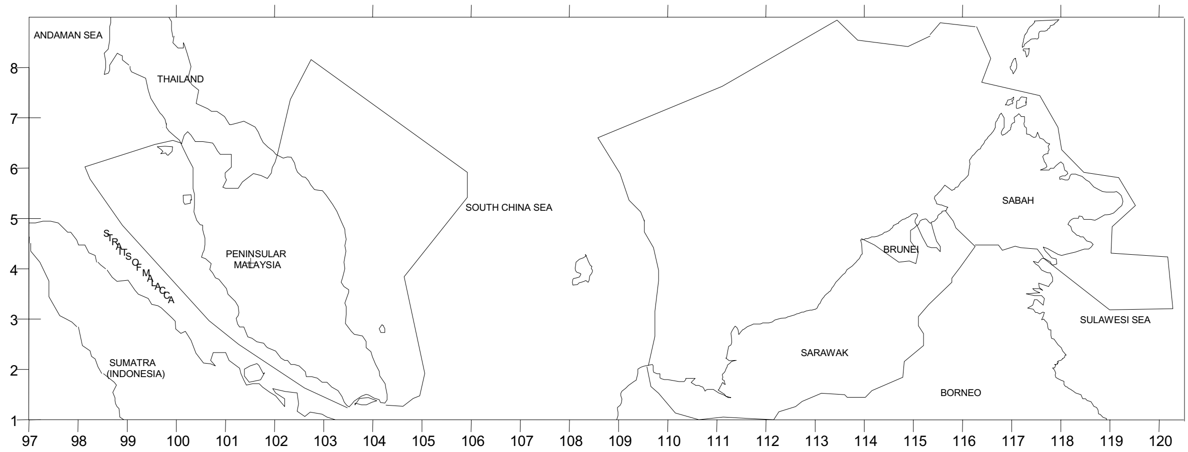


**Figure 1. Map of Malaysia**

Being in the tropics, and with the availability of essential factors conducive to excellent growth of aquatic organisms, the waters are rather productive. Harbouring a multitude of different varieties of tropical fish and other marine fauna, the fisheries themselves have been termed multispecies and multigear in nature. The fishing waters of Malaysia extends from the shoreline to the EEZ demarcation line, which on the Peninsular east coast and in Sarawak and some parts of Sabah can stretch up to 200 nautical miles. The total estimated area of this domain is 91 600 sq. nm, consisting of some 14 800 sq. nm on the west coast of Peninsular Malaysia, 32 600 sq. nm on the east coast of the Peninsula, 36 800 sq. nm in Sarawak and 7 400 sq, nm on the west coast of Sabah.

## 2.2 Brief history of the fisheries

As in other Southeast Asian countries, the Malaysian fisheries prior to the 1960s were mainly artisanal in nature. Traditional fishing using hooks and lines in small non-motorized boats was common in most waters, as with the use of other traditional gears like drift nets, lift nets, bag nets, barrier nets and push nets. At strategic locations on the waters near some estuaries, man-made wooden stakes and platforms harbouring some shelters and submerged fishing traps were quite common. Known locally as *kelong*, these stationary traps bear some resemblance to the many other smaller and immobile fish traps known locally as *pompang* and *gombang* (bag nets), which were placed by fishers in the waters close to the coastline of the country.

Information on fish abundance during these early times is scant due to the absence of any credible resource surveys, but it is generally agreed that the waters were greatly infested with fish. Tiews (1965) estimated fish density in the continental shelf area of Malaysia less than 50 m deep as 12 tonnes/sq. nm, not considering the shallower near-shore waters would generally have higher concentration of fish than offshore waters. No attempts were made during these early periods to keep accurate records of landings at any site within the country.

While there was a general lack of information concerning the actual number of fishers involved, the large number of fishing villages found existing along the coastline probably means that tens of thousands of people indulged in some form of fishing activities for their subsistence.

Significant changes, however, occurred in the 1960s, when synthetic fibre and trawl were first introduced (Mohd Ibrahim, 1987). The new fibre that gradually replaced the traditional natural fibre had a number of advantages when used as fishing nets. Compared to natural fibre, the synthetic fibre showed longer durability in water, had a higher tensile strength, and made the net more economical in terms of maintenance, time consumption and manpower usage. Because of its clear superiority, the new netting material gained popularity very rapidly. By 1962, fishing nets made from the synthetic material were used throughout the major fishing areas, starting from the west coast, then expanding to the east coast, and later to East Malaysia.

Trawl nets were introduced in 1963, starting with a single boat of about 20m in length. By July 1966, ten boats on the west coast of Peninsular Malaysia were converted into trawls, and by December of the same year, 40 trawlers were operating in the coastal waters (Mohd Ibrahim, 1987). At the end of the ensuing five-year period, a total of 1 349 trawl licences were issued by the Department of Fisheries Malaysia (DOFM). Use of trawls spread rapidly throughout the country, and became a major contributor towards the increase in catch of the demersal fish. The number of trawlers rose rapidly, and in 1982 a total of 6 109 units was licensed (Figure 2). With the opening of new fishing areas in 1987 in the EEZ waters of the country, additional licences were issued making the total number of trawls in 1989 at 6 384 units. In an effort to reduce fishing pressure in the coastal waters, the number of trawlers operating was reduced, and in 1996 the total number of trawlers estimated in operation around the country was around 5 619 units.

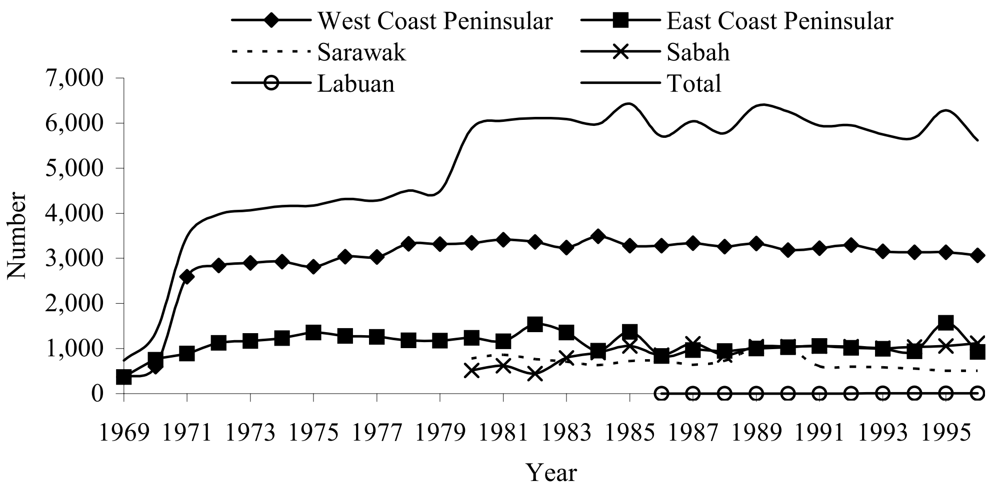


**Figure 2. Number of trawlers licensed in Malaysia with respect to area of operation**

Introduction of engine-fitted vessels to facilitate fishing began some time after the end of the First World War. Mechanized fishing vessels had been used in the coastal waters of the west coast as early as the 1930s, but only introduced to the east coast in 1950. East Malaysia probably developed such vessels about ten years later. In 1960, about 38 percent of the fishing vessels in Peninsular Malaysia were already mechanized, but in East Malaysia the number was less than five percent.

The percentage of mechanized fishing vessels in Peninsular Malaysia also increased steadily up to 74 percent in 1970, 82 percent in 1980, and 97 percent in 1990. In East Malaysia, this number rose rapidly from a mere five percent in 1960 to 78 percent in 1970, then gradually up to 80 percent in 1980 and 95 percent in 1990. In 1996, a total of 30 592 fishing vessels in Malaysia were mechanized, of which 5 619 units were trawlers, 12 166 units were gill net vessels, and 1 779 units hook and line fishing vessels.

Besides mechanization of the fishing vessels, changes also occurred in the vessel size, especially for trawlers. In the early 1970s, most trawlers were considered as small (of less than 40 GRT), a few were medium size (40-69 GRT), and none exceeded 70 GRT. In the 1980s, ten super trawlers (of size greater than 70 GRT) were first licensed. By 1990, the number of these trawlers had increased to 184. In 1996, a total of 565 fishing vessels, of size 70 GRT and above, were licensed. A majority of these were trawlers.

During the early period of operation, no restrictions were placed on the trawlers undertaking fishing. They were allowed open access into all marine waters, even those near to shore. This inevitably led to conflicts and general feelings of unrest amongst the traditional fishers, who viewed these trawlers as competent poachers that threatened their livelihood and available resources.

To put matters to rest, the DOFM issued an important requirement in the early 1970s that trawlers were prohibited fishing in waters less than three nautical miles from shore. In the early 1980s, the zone system was created, and this prohibited area was expanded to encompass five nautical miles from shore.

Gill nets, lift nets, bag nets, barrier nets, traditional seine nets, portable traps and hook and lines are some of the fishing gears that have long been classified as traditional and their operation not believed to have a serious impact on the sustainability of fish resources. Under the zone system, these gears are allowed to fish in coastal waters less than five nautical miles from shore (Zone A), and are also unrestricted from going beyond. Small trawlers of less than 40 GRT are allocated the coastal waters beyond the five nautical-mile limit up to twelve nautical miles (Zone B). Medium-size trawlers (40-69 GRT) are required to fish in waters slightly further away, at least twelve nautical miles from the shoreline (Zone C). Trawlers exceeding 70 GRT are categorized as offshore fishing vessels, and only allowed to operate in waters beyond thirty nautical miles (Zone C2). By designating the gears to the various zones of waters, DOFM hoped to avert any conflicts that might arise between fishers racing (or scrambling) to fish for the same resources.

The history of trawl fish landings in Malaysia between 1971 and 1996 is illustrated in Figure 3. The peak of around 330 000 tonnes in 1978 was achieved from fishing in coastal waters of less than 30 nautical miles from shore. As can be seen, trawl landings began to decline after 1978, but rose sharply again to around 440 000 tonnes in 1987 with the opening of new fishing grounds in the offshore waters. Trawl catches showed some slight increase after this period, and the landings then appeared to stabilize at around 600 000 tonnes in 1995. This value is about 54 percent of the total fish landings by all gears in Malaysia (Figure 4).

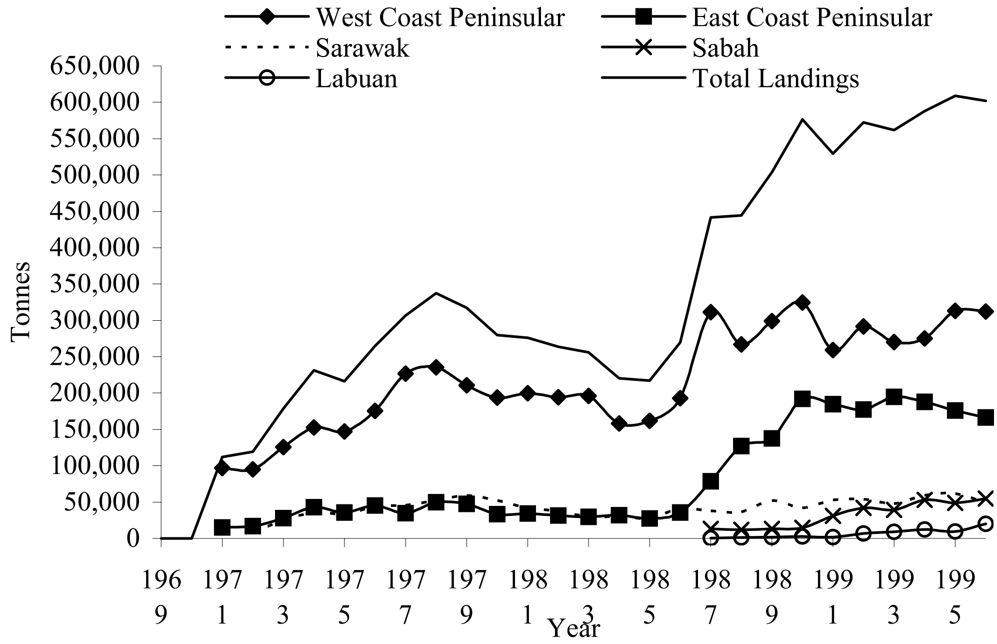


**Figure 3. Trawl fish landings in Malaysia between 1971 and 1996**

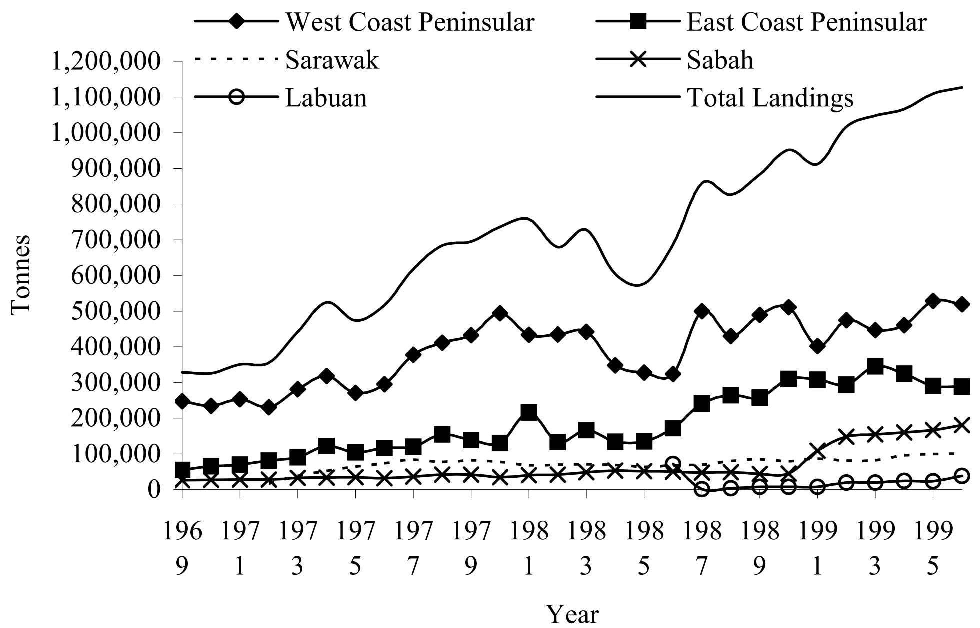


**Figure 4. Fish landings by all gears in Malaysia (1969 - 1996)**

## 2.3 Problems besetting the fisheries

Some of the major problems that have been identified and associated with the Malaysian fisheries are as follows:

*2.3.1 Excessive fishing and resource overexploitation*

The increase in number, size and efficiency of trawlers, coupled with the general improvement in fishing capability of the other existing gears, greatly increased the fishing pressure on the available fish stocks. Signs indicating excessive fishing might have occurred started to appear in the mid 1970s from the inshore waters (less than five nautical miles from shore) of both the west and east coast of Peninsular Malaysia. At the end of the 1970s, words filtered into the DOFM from fishermen that some fish species (like the "shrumbu" fish, *Lactarius lactarius*) were getting scarcer and near depletion. Other species of commercial importance also became less abundant, while changes in species composition and size among the dominant groups of fish became more apparent. Signs are now appearing that this phenomenon has probably spread to some parts of the offshore waters of Peninsular Malaysia as well.

*2.3.2 Technological modification of fishing gears*

The potential mobility of most fishing gears to upgrade their harvesting performance and in most cases the other negative influences simultaneously imposed on the environment and marine ecosystem, is a major concern that needs a proper discourse in an effective management system. In multispecies tropical fisheries like those in Malaysia, the constraints imposed generally take the forms of the do's and don'ts relating to the characteristics and specificity of the fishing vessels and gears. For example, the Two-boat Danish Seine, a traditional gear employed to catch prawns in some waters on the west coast of the Peninsular, has since the past two decades been modified by fishers to resemble pair trawling. This led to greater quantities of prawns and juvenile fish being caught by the boats than what were originally being caught. Enforcement strategies to counter such aberrations as in this case were given serious considerations by the DOFM, and monetary penalties normally imposed on errant fishers to discourage such actions.

*2.3.3 Encroachment fishing*

Without doubt, this has always been the *greatest* concern of the DOFM to bring some control and order to the various fisheries. Some of the larger fishing vessels, especially the big trawlers with their greater fishing capacity, are occasionally caught fishing in waters further inshore (i.e. outside their designated areas), which brings considerable feelings of unrest among the legitimate fishers operating within the area. Severe monetary penalties are normally imposed on offenders, and if caught several times may even lead to gear and vessel confiscation and even jail sentences. In the offshore waters of the country, especially in Peninsular Malaysia, the frequent occurrence of encroachment fishing by *foreign* vessels is another serious concern of the DOFM, which together with other governmental enforcement bodies patrolled these waters for the safety of the country and to discourage such activities.

## 3. MANAGEMENT MEASURES AND APPROACHES

Management measures and approaches developed and continually improved by the DOFM beginning from the 1960s to regulate fishing activities are many. Briefly, these include, *inter alia*, the technical measures, effort controls and limited access.

Some of the technical measures currently imposed include area and time restrictions, and gear restrictions such as specifying the minimum mesh sizes of fishing nets. For example, close fishing seasons and areas, and total fishing prohibition within specific stretches of marine waters (e.g. waters of the Marine Park). The minimum cod-end mesh sizes of prawn and fish trawl nets have been set at ¾-inch and 1½-inch when stretched (Department of Fisheries Malaysia, 1999). The use of turtle excluder devices (TEDs) on prawn trawl nets is increasingly becoming mandatory.

Input controls include restrictions on the number of fishing units through limiting the number of licences or permits issued, and restrictions on the body and engine sizes of fishing vessels. The maximum engine power (in horsepower) fitted for trawlers should not exceed 4.40 times their GRT, and for purse seiners, engine powers (in horsepower) are only allowed up to 3.47 times their GRT. Vessels employing traditional gears should have engine powers not exceeding 3.40 times their GRT. The amount of time that these units can spend fishing is, however, still not limited.

Limited access is becoming more important as a means to avoid unwarranted conflicts between fishers operating the different fishing gears. In Malaysia, the zone system employed is able to provide ample fishing grounds for the respective gears to fish, and surveillance activities are constantly conducted to ensure the gears do not infringe the terms and conditions stipulated for their operation.

As with other responsible fisheries management authorities, the DOFM undertakes seriously the task of monitoring, control and surveillance of the respective fisheries under its management strategies. Various trained staff belonging to the Department are assigned specific duties to ensure the objectives under this extremely important programme are fulfilled.

## 4. MONITORING, MEASUREMENT AND ASSESSMENT OF FISHING CAPACITY

Monitoring involves the collection, measurement and analysis of data and information on fishing activities (FAO, 1997). In Malaysia, this very important aspect is undertaken by two divisions of the DOFM — the Research Division and Statistics Division. The Research Division also undertakes fish resource surveys at specific intervals using research and commercial vessels. This is in order to periodically estimate the status of the fish resources, including the stock biomass (both demersal and pelagic), exploitable potentials (and maximum sustainable yields) and exploitation rates.

### 4.1 Monitoring fishing capacity of all major gears

#### *4.1.1 Data on catch-efforts and landings*

Catch and effort data of all major fishing gears, are collected monthly by trained staff at all major fish landing centres. The sample consists of at least 20 percent of the number of fishing gears in use. Depending upon the gear used and location, sampling is normally undertaken during the fish landing process, this being either in the early morning or late afternoon. Choice of vessel is at random, being based on availability while sampling is being conducted. Data on all fish species or groups of species are recorded as these vessels land and weigh their catch, even those considered to be trash. Sub-sampling is undertaken for groups of fishers with excessively high catches to gain an estimate on their species composition. Catches from vessels that do not complete their normal fishing day, for example due to engine breakdown or other problems, are not considered in the sampling.

Among the information recorded during sampling are:

- name of fishing gear and type;
- number of gears in operation;
- number of days fishing at sea;
- number of times the gear is set/day;
- number of hours the gear is fishing;
- total weight of catch; and
- weight of each species (or groups of species) in the catch.

The catch data from each gear sampled are then averaged to indicate the gear's fishing capacity and raised to the total number of gears in operation within the month to obtain the monthly landings.

#### *4.1.2 Evaluation of the data collection process*

Clearly for data that are obtained manually, their accuracy would depend largely on the knowledge and skill of the person doing the sampling. With the existence of a work force of diverse capabilities within the Department specifically geared for this purpose, sampling guidelines have been introduced to achieve some form of uniformity in the collection process. The taxonomic proficiency of this group of samplers, especially in the identification of unusual species that might be present in the catch, is continually being upgraded through various training in fish taxa given periodically by experts from the Research Division of the DOFM or the University.

#### *4.1.3 Data processing, storage, accessibility and publishing*

Data are recorded manually onto specially prepared forms and forwarded to the Fishery State Office according to sub-areas and states for computer storage in a database and analysis. Trained staff from headquarters undertakes the responsibility of generally preparing these data for publication.

The computer software employed for data storage has been named the National Integrated Database Management System (NIDBMS), which was developed specifically for the purpose by staff belonging to the Department and experts from Canada. Access to these data by outsiders via telephone lines is now made possible, but permission must first be obtained from the management concerned to ensure data safety within the Department is not compromised.

The processed data and relevant information related to fish landings and the fisheries are published yearly by the DOFM as *Annual Fisheries Statistics*.

### 4.2 Data analyses

Data on the catch and efforts of fishing gears in operation are periodically analyzed to obtain up-to-date information on the gear's performance as well as to generate some estimation on the sustainable exploitation of the resources. Much emphasis is generally placed on the trawlers for their greater ability to exploit the demersal resources compared to traditional gears. On these aspects, the following methods are employed:

*4.2.1 Catch trends*

Catch trends, either as landings or CPUE, of the respective gear under investigation denote the gear's performance in the fishery. Assuming each individual gear in the group follows a similar pattern of fishing (e.g. number of days at sea, number of hours the gear is set in the water, etc.) and that the total number of gears operating kept constant, the observed trend provides some forecast of the state of the fishery as well as the expected future catches. When the fishery is doing well, the trend should be on the rise or fluctuated along a given horizontal line. When problems arise in a fishery, such as the amount of fish resources are being gradually diminished, the observed trend would likely to be decreasing.

*4.2.2 Surplus production models*

The general absence of mathematical models specifically developed for use on tropical fish stocks means that models initially developed for the temperate stocks are also being used *cautiously* to provide some estimates on the maximum sustainable yield (MSY) from the fishery. In this, the use of surplus production models (particularly Schaefer's and Fox's Models) gains rather a wide acceptance in Malaysia.

The concept of surplus production models to produce maximum yield was first introduced by Graham (1938) and modified by Schaefer (1954) and Fox (1970). Two forms of production function were widely used here: the logistic Schaefer (1954) and exponential Fox (1970) models. These models are based on the concept that the stock is considered as a big "lump" of biomass and no attempt is made to model on an age or length base.

The following equations are employed in the analyses using the two models. The Schaefer model is given by:

$$Y(i)/f(i) = a + b\,f(i) \quad \text{or}$$
$$Y(i) = a\,f(i) + b\,f(i)^2 \quad \text{if } f(i) =< -a/b \tag{1}$$

where $Y(i)$ is the catch in year $i$ ($i = 1, 2, 3, \ldots., n$), $f(i)$ is the total level of fishing effort, and $a,b$ are estimated parameters. From this, the level of effort that produces maximum sustainable yield (MSY) and the actual MSY can be deduced, given by:

$$f_{MSY} = -0.5\,a/b \quad \text{and} \quad MSY = -0.25\,a^2/b \tag{2}$$

Similarly, the Fox model is given by:

$$Y(i)/f(i) = exp\,[a + b\,f(i)] \quad \text{or}$$
$$Y(i) = f(i)\,exp\,[a + b\,f(i)] \tag{3}$$

giving $$f_{MSY} = -1/b \quad \text{and} \quad MSY = -(1/b)\,exp\,[a - 1]$$

In multigear fisheries such as those in Malaysia, the effort $f(i)$ used in these analyses is the total standard effort ($f_{Tot\ Std}$), estimated by standardizing all other gears (j) that exploit similar resources within the area to the standard gear (s) through the following formula:

$$\text{Total standard effort } (f_{\text{Tot Std}}) = X_s + \sum_j K_j X_j \quad (4)$$

where $X_s$, $X_j$ are the number of fishing effort units (e.g. days, hours) of the standard gear, *s*, and other gear, *j*, respectively; and $Y_s$, $Y_j$ are the total catch (in weight) of standard gear, *s*, and other gear, *j*, respectively. Given this, $K_j = (Y_j/X_j) / (Y_s/X_s)$ is a measure of relative catch per unit of effort for the given gear types.

## 4.3 Monitoring the state of fish resources

Besides monitoring the fishing capacity of the various gears in operation, DOFM also monitors periodically the state of the fish resources to enable up-to-date management remedial actions to be taken to conserve and enhance the fishery resources if required. The stock assessment programmes normally undertaken are fish resource surveys. The main objective of such surveys is to provide the latest estimates on the demersal and pelagic fish stocks, in terms of density or biomass, both in the coastal as well as in the offshore waters of Malaysia.

### *4.3.1 Demersal fish resource surveys*

Demersal resource surveys in the coastal waters (less than 30 nautical miles from shore) in one part of the country or another within the last three and a half decades are common, being almost an annual affair. The first of such surveys was probably the exploratory trawling conducted by MV SELAYANG in the area between 10 - 50 m deep on the west coast of the Peninsula in 1965 (cited in Chee *et al.*, 1998), which provided an average catch rate of commercial and trash fish of about 168.6 kg/hour. On the east coast, the first demersal survey undertaken in 1967 recorded a catch of around 438 kg/hour (cited in Mohd Taupek *et al*., 1999).

Numerous surveys ensued even up to present times (Ahmad Adnan, 1984, 1986, 1988a, 1988b; Mohd Taupek and Ibrahim, 1990), but within the Malaysian EEZ only two comprehensive surveys have so far been completed: the first in 1987 by the research vessel *RV Rastrelliger* (Anon. 1988), and second, being the most recent, in 1998, by *KK Manchong*. In this last survey, average catch rates of 55.3 kg/hour (west coast Peninsula), 29.7 kg/hour (east coast Peninsula), 138.1 kg/hour (Sarawak) and 126.0 kg/hour (west Sabah) were obtained (Abu Talib and Mohd Taupek, 1999).

Comparison between *KK Manchong* (1998) and *RV Rastrelliger* (1987) in similar waters provided some alarming results. Demersal fish biomass had declined drastically on the west and east coasts of Peninsular Malaysia (by 60 percent and 88 percent, respectively), and only slightly in Sarawak (by 14 percent), but of still considerable concern in Sabah (by 44 percent) (Abu Talib and Mohd Taupek, 1999). In all the surveys, the ‘swept area’ method, using a trawl as the main sampling gear, was adopted.

The ‘swept area’ method provides an estimate on the density of fish per unit area and also valuable information regarding the fish distribution and species composition. The area to be surveyed is first demarcated into grids to determine the actual area of coverage. Grid size is dependent on the sampling density; a small grid indicating a high sampling density is to be attempted, and *vice versa*. Standard one-hour trawl stations are placed at random within each of the grids, covering all the respective areas. Trawl fishing is conducted at the stations using a standard speed (4 knots for fish and 2.5 knots for prawn) and a warp length to depth ratio of 5:1, and the catch obtained analyzed (usually in terms of weight and number).

### *4.3.2 Estimating the fish biomass*

If the weight of catch per haul is $C_w$, then $C_w/t$ is the catch per unit time when $t$ is the duration of the trawl haul. If $a$ is the area swept by the trawl haul, then $a/t$ represents the area swept per unit time. The effective net opening is estimated by using other methods, such as the SCANMAR Trawl Monitoring System. The weight of catch per unit area is thereby given as:

$$(C_w/t)/(a/t) = C_w/a \tag{5}$$

The mean weight of catch per unit area $(C_w/a)_{mean}$ divided by $q$ (the catchability coefficient) gives the average biomass per unit area. The catchability coefficient represents the amount of fish caught by the trawl relative to that which manages to escape. When $q$=0.5, only 50 percent of the fish in the path of the trawl were caught. When $q$=1.0, all of the fish in the path of the trawl were assumed to be caught. The biomass ($B$) of the whole area surveyed ($A$) is:

$$B = (C_w/a)_{mean}/q * A \tag{6}$$

Pelagic fish species were normally excluded from the biomass calculation because they do not remain permanently in the bottom layers of the sea to be available to the trawl. Pelagic fish also tend to show schooling behaviour and are, therefore, not uniform in their distribution.

### *4.3.3 Estimating the exploitable potential*

Gulland's formula (in Sparre and Venema, 1992), given by:

$$MSY = ½ MB_v \tag{7}$$

is used to estimate the maximum sustainable yield ($MSY$) when stocks are unexploited or in the virgin state. In this case, $M$ is the natural mortality coefficient and $B_v$ is the virgin biomass. If the yield follows the Fox Model, MSY is determined by:

$$MSY = 0.37\ MB_v \tag{8}$$

Gulland's formula was modified by Cadima (in Sparre and Venema, 1992) to determine the MSY of exploited stocks. In this case, $M$ is the natural mortality, $Y$ is the yield and $B_c$ is the current exploited biomass. MSY is given by:

$$MSY = 0.5 * (Y + MB_c) \tag{9}$$

For stocks that are exploited, MSY can also be calculated using the equations proposed by Garcia *et al*. (1989) given by:

$$MSY = M^2B_c^{\ 2}/(2MB_c\text{-}Y) \tag{10}$$

based on the Schaefer Model, or:

$$MSY = MB_c \exp((Y/MB_c)-1) \tag{11}$$

based on the Fox Model. As before, $Y$ is the current yield, $M$ is the natural mortality coefficient and $B_c$ is the current biomass.

In determining MSY, two values of $q$ were normally used (i.e. $q$ = 0.6 and $q$ = 1.0). Three values of $M$ (i.e. 0.6, 1 and 2) can be used to provide options in different scenarios. The current yield taken from the area surveyed was generally estimated from the latest landings of commercial trawlers operating within the area.

*4.3.4 Estimating the exploitation rate*

The exploitation rate ($E$) is a fraction of total death ($Z$) caused by fishing ($F$). Since $F=Y/B_c$ and $Z=F+M$, the exploitation rate can be estimated by:

$$E = (Y/B_c)/(Y/B_c + M) \tag{12}$$

*4.3.5 Length frequency data analysis*

Length frequency data analyses on selected species were generally undertaken to extract the von Bertalanffy growth parameters, mortality and exploitation rates by species.

*4.3.6 Maturity studies on fish and cephalopods*

Development stages of fish gonads were generally differentiated as immature (I-II), maturing (III-VI) and spent (VII) based on visual observation. The sex ratios of male to female fish were also usually calculated. To determine the maturity index of female cephalopods, the Nidamental Gland Index (NGI = nidamental gland length / dorsal mantle length X 100) was used, and for males the Hetecocyt Index (HI = hetecocyt length / dorsal mantle length X 100) was used (Mansor *et al*., 1999).

*4.3.7 Pelagic fish resource surveys*

Compared to demersal surveys, the use of acoustic surveys to estimate the amount of pelagic fish was less common. The first comprehensive acoustic survey, covering part of the coastal waters and all parts of the Malaysian EEZ, was by the research vessel *RV Rastrelliger* in 1986-87. In early 1994, a DOFM training vessel, *KL Paus*, attempted a similar survey in the coastal and offshore waters on the west coast of the Peninsula, but results obtained were unconvincing. The *MV SEAFDEC* acoustic surveys, conducted collaboratively by Malaysian and Thai researchers, estimated pelagic fish abundance in the waters of the Gulf of Thailand and east coast of Peninsular Malaysia during the pre-Northeast Monsoon (September 1995) and post-Northeast Monsoon periods (April/May 1996). The survey was later extended to Sarawak and Sabah waters in July-August 1996 (pre-Monsoon) and May 1997 (post-Monsoon).

The most recent acoustic survey was the one conducted in 1998 by another DOFM training vessel, *KL Cermin*. Using the scientific echo sounder Furuno FQ-70M, the survey provided pelagic fish biomass estimates of 311 000 tonnes (west coast Peninsula), 733 000 tonnes (east coast Peninsula) and 1 705 000 tonnes (Sarawak and Sabah) (Raja Bidin *et al*., 1998). No distinguishable signs of pelagic stock depletion were observed on comparison with estimates obtained by earlier surveys.

*4.3.8 Present status of the fish resources*

At present, overexploitation of demersal fish resources probably occurs in most parts of the Malaysian waters. Areas that have now been identified include the coastal and offshore waters of both the west and east coasts of Peninsular Malaysia, and the coastal waters of both Sarawak and west Sabah. In the offshore waters of Sarawak and Sabah, the demersal resources are still being under exploited and thus still provide potential for further expansion of the deep-sea trawl fishery. The pelagic fish resources in Malaysian waters to date have still not shown any clear sign of excessive exploitation and their fisheries can probably still accommodate further expansion.

## 4.4 Fish conservation and enhancement programmes

Conservation and enhancement measures were undertaken by the DOFM for a number of reasons, one of which was to alleviate the declining coastal demersal stocks first observed in the mid-1970s. Such measures include the building of artificial reefs made from specific units of building material as sanctuaries and breeding grounds for the aquatic resources and defining specific stretches of waters as protected areas and Marine Parks.

The use of old tyres as the unit building material of artificial reefs was extremely popular at one time, as these items were known to have high durability in water and also were non-toxic when decomposed (Sukarno *et al*., 1994). Reefs were also made from other materials such as concrete, condemned fishing vessels, plastics (PVC or FRP), natural rocks and parts of trees (such as stems and palm leaves).

In 1975, the first artificial reef using old tyres was launched at the Pulau Telur (Kedah) coastal waters on the west coast of the Peninsula by DOFM (Sukarno *et al*., 1994). In 1984, a nation-wide campaign was launched by the Honourable Minister of Agriculture for the purpose of collecting old tyres for reef-building. A targeted amount of 1.4 million old tyres was initially specified, these to be assembled in complex pyramidal blocks comprising of 28 000 units or more per site. By the end of 1993, an estimated three million old tyres had been collected and placed at 67 coastal sites around the country (38 sites on the east coast Peninsula, 16 on the west coast Peninsula, six in Sarawak and seven in Sabah) at depth ranging between 15-25 m (Sukarno *et al*., 1994). Fish life developed positively at these sites, but making an accurate assessment of the actual abundance was difficult. At one site, an angling catch rate of 8.7 kg/hour/man was mentioned.

The creation of marine protected areas (such as the Marine Parks) is another important measure to curb the decline in the coastal demersal resources. By this, the surrounding waters enclosing certain islands from shore up to a distance of three km were totally prohibited from *any* form of fishing. To facilitate the proper management and administration of these parks, the DOFM has established Marine Park Centres on some of the major islands. These Centres, which help provide information to visitors on the various interesting features present on the islands under their jurisdiction, are staffed by DOFM personnel. Well equipped for such educational purposes, these Centres also serve as a base for research, enforcement and monitoring of activities in the park areas.

In Malaysia, the endeavour to establish marine parks was first initiated in the early 1980s. In late 1983, the Ministry of Agriculture took responsibility for protecting and conserving some strategically located important islands and their surrounding maritime waters in a more effective manner. The Minister was empowered to establish any area within Malaysian fisheries water as a marine park and marine reserve for the purposes of:

1) protection of marine life;
2) protection, preservation and management of breeding areas, particularly of rare and endangered species;
3) natural regeneration of aquatic life in depleted areas;
4) promotion of scientific research;
5) preservation and enhancement of the natural state and productivity, and
6) regulation of recreational activities to avoid irreversible damage to the environments.

To date, a total of 40 islands have been declared as Marine Parks of Malaysia. While recent assessments on the implementation of these measures had indicated some measures of success, more efforts are still needed to stem the general degradation of the fish resources.

## 5. FUTURE OUTLOOKS

In light of recent findings, the DOFM is at present in the process of formulating two major research programmes under the Eighth Malaysia Plan (2001-2005):

### 5.1 Management of sustainable capture fisheries programme

Activities proposed under this programme include:

(a) *Monitoring of fish landings*: Monitoring fish catches of vessels operating in the coastal and offshore marine waters, as well as those from the inland water bodies and rivers.
(b) *Management of fishing activities*: Economic feasibility studies on the coastal and offshore vessels employing commercial and traditional gears.
(c) *Monitoring the status of fish resources*: Fish resource surveys (both demersal and pelagic) in the coastal and offshore waters; prawn resource surveys; studies on the spawning season of fish, crustaceans and cephalopods; studies on the distribution of fish eggs and larvae.
(d) *Monitoring and development of fishing technology*: Development of echo-friendly fishing gears and fish juvenile excluder devices.
(e) *Conservation and enhancement of fishery resources*: Ecosystem studies on mangroves, sea grass and coral reefs; studies in marine, brackish water and freshwater biodiversity; sea ranching; conservation of endangered species.

### 5.2 Fisheries development programme

Activities proposed under this programme include:

*(a) Capture fisheries development in Peninsular Malaysia*: Fish resource surveys on the high seas and international waters (Indian Ocean and South China Sea); studies on the

feasibility of using purse seining and hooks and lines on the high seas and international waters; studies on FAD designs for recreational fishing on the high seas.

(b) *Capture fisheries development in Sarawak*: Fishing gear development in offshore waters; development of recreational fishing; studies on fishing gear development in untrawlable areas.

(c) *Capture fisheries development in Sabah*: Fishing gear development in offshore waters; development of recreational fishing; development of tuna fisheries; studies on fishing gear development in untrawlable areas.

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# MONITORING, MEASUREMENT AND ASSESSMENT OF FISHING CAPACITY: THE NIGERIAN EXPERIENCE

**A.V. Amire**[1]

**Abstract**: Nigeria has an 853 km coastline and an entire maritime waters of 210 900 km$^2$ including the Exclusive Economic Zone (EEZ). The continental shelf is narrow, extending for only about 15 km in the western area and ranges from 60-80 km in the eastern tip. This condition limits the trawlable grounds to 3 200 nm$^2$ out of the 11 470 nm$^2$ continental shelf area. The inshore (0-50m) waters are characterized by a variety of small fish species varying from 25 to 50 cm in total length. The most predominant is the *Pseudotolithus* spp. Estimated potential yield of the inshore waters is about 16 620 mt for finfish and between 3 500-4 020 mt for shellfish resources, which are exploited by both the artisanal and industrial operators. Offshore (50-200 m), the potential fisheries resources are estimated at about 9 460 mt, and consist of mostly tuna and tuna-like fishes.

In this paper, the diverse inshore and offshore fisheries resources and the various capacities employed in harvesting them are discussed. In some of the fisheries, harvesting has been in excess of the annual potential yield due to excess effort and overcapitalization. The number of inshore trawlers rose from 92 in 1979 to 350 in 1998. The need for an effective effort/capacity measurement mechanism is, therefore, imperative. Various methods adopted for capacity measurement and monitoring fisheries resources are presented and analyzed.

## 1. INTRODUCTION

Nigeria occupies between latitude 4$^o$16’ and 13$^o$52’N, longitude 2$^o$49’ and 14$^o$37’E, and has a coastline spanning about 853 km bordering the Gulf of Guinea in the Atlantic Ocean. The Nigerian coastline is indented with lagoon systems in the west, extensive mangrove swamp and a delta (Niger-Delta) complex which opens into the sea through a host of rivers including Benin, Escravos, Forcados, Ramos, Dodo, Middleton, Fish town, Nun, Brass, San Batholomeo, Bonny and Opobo. The Niger Delta system is the second largest in the world and spans a distance of about 500 km. Most fin and shellfish resources of the Nigerian marine waters are found within this region.

Nigeria declared an Exclusive Economic Zone (EEZ) of 200 nm in 1978 thus extending her area of maritime influence including the Territorial waters to an estimated 210 900 km$^2$. Fishing has been the dominant occupation of most inhabitants of the coastal regions of Nigeria, and activities have been mostly from the artisanal sector, producing between 80–90 percent of Nigeria’s annual fish supply. The industrial fisheries sub-sector’s growth from 1987 to date has been phenomenal and this calls for effective resource management strategies.

The estimated annual fish demand in Nigeria is 1.2 million metric tonnes based on a population figure of 100 million and per capital consumption of 12 kg per annum regarded as adequate for a normal healthy growth. The current total annual fish supply is about 50 percent of the total demand. This excess demand encourages the deployment of more effort into the fishery with the objective of reducing the gap between demand and supply. The over capitalization that has subsequently developed has resulted in reduced catch per unit effort (CPUE) in the last couple of years. Managers of the resource are worried about this trend. There is, therefore, a need to constantly monitor the capacity deployed into the fishery to avert over-fishing and the consequent resource depletion.

[1] Federal Department of Fisheries, Lagos, Nigeria.

A Fisheries Resources Monitoring, Control and Surveillance Unit in the Federal Department of Fisheries of the Federal Ministry of Agriculture and Rural Development was established by the Government in 1991. Its main function is to ensure rational exploitation and sustainable management of the nation's marine fisheries resources due to the threats posed by poaching increased fishing effort and capacity, particularly over the inshore waters.

## 2. COASTAL TOPOGRAPHY AND OCEANOGRAPHY

The topography and hydrographic regimes of the West African continental shelf affect the distribution and constituents of the benthic animal communities. Oceanographic surveys also indicate that prevailing hydrographic conditions influence fish productivity along the continental shelf.

The Nigerian coast can be divided into four main physiographic zones, namely, the Barrier Lagoon Coast with steep beach profiles and sandy bar plain stretching about 200 km from the west; the Mahin Mud Coast which grades from the sandy into a mud beach and extends about 75 km to the Benin River mouth; the Niger Delta which spans from the Benin River to Imo River is renown for its fin and shell fish resources; and the Strand Coast which extends for 85 km from Imo River to the Cross River estuary is characterized by active mixing of river and sea waters. It harbours fish species similar to those of the Niger Delta.

The continental shelf widens progressively from 15 km off Lagos in the west to about 80 km off Calabar in the southeast. The relatively narrow continental shelf limits trawlable grounds and fish abundance. The area of the shelf is about 11 470 square nautical miles ($nm^2$) of which 3 200 $nm^2$, representing only 27.90 percent, is trawlable (Tobor, 1990). The 40 m contour is a reliable boundary of the thermocline which separates the upper from the lower oceanic currents and limits the extent of the distribution of demersal fish stocks. Hence, this zone between the high water mark on the shore and the 40 m-depth contour running parallel to the coast at an average distance of 37 km from the shore contains the demersal fish resources, which provide opportunities for further development of the artisanal and coastal inshore fisheries. Artisanal fishermen almost exclusively fish the region between the shoreline and the 18 m contour, but both the artisanal and industrial fishermen exploit the resources between the 18 m and 40 m contour.

The most significant features of the hydrographic regime in the Nigerian waters include the relatively stable thermocline, steep temperature gradient and stable oceanographic conditions below the mixed layer throughout the year. Hydrographic conditions in the coastal waters are greatly affected by the effluent rivers, the effects of which depend on the average annual discharge. This is greatest in the Niger-Delta area where the total discharge is about 21 800 $m^3$.

There is a definite pattern in the distribution of fishes on the Nigerian continental shelf. Available data indicate that the distribution of a number of species is limited by the depth of the thermocline and is influenced by the type of deposit (sand, silt) and the depths on the continental shelf, the slope of which is variable. Though the broad distribution of the commercially exploited marine fish species is known, there is limited information on the composition of communities and spatial distribution of stocks. The distribution of demersal and pelagic fishes in the marine waters of Nigeria indicates discrete ecological fish communities, each of which is fairly homogenous. There is, however, also ecological and microgeographical heterogeneity of fish communities. Migration of species from the estuaries and creeks to the open and continental shelf areas and vice versa is known to be of common occurrence.

## 3. STATUS OF THE MARINE FISHERY

Nigeria has two major marine fisheries sub-sectors: the artisanal or small-scale and the industrial or trawl fisheries. Marine artisanal fisheries activities are divided into two major components: the brackish water fisheries with fishing activities in the creeks and estuaries where freshwater flowing down the rivers mixes with salt water moving up with high tide; and the artisanal inshore fisheries with fishermen operating in waters of less than 40 m depth.

### 3.1 Brackish water fisheries

The brackish water fisheries are an important component of Nigeria's artisanal fisheries consisting of estuaries, beach ridges, intertidal mangroves swamps, intersecting rivers and numerous winding saline creeks. Data based solely on the production from this sector are not available but fishing intensity is known to be high. Small dug-out canoes that are generally non-motorised are used by fishermen operating within this area.

### 3.2 Coastal/inshore pelagic fisheries

The family *Clupeidae* constitutes the principal element in Nigeria's coastal/inshore pelagic fish community, the most important of which is the *Ethmalosa fimbriata* (bonga). Other key species are the shad (*Ilisha africana)* and the flat sardine (*Sardinella maderensis)*. The bonga is the most valuable and abundant fish in the artisanal fisheries of Nigeria. It is euryhaline and the juveniles tolerate low salinity in the Niger Delta river mouths. Adults and spawners are located in the downstream estuaries and at sea. It rarely goes below 20 m and prefers warm and turbid waters. *Ilisha africana* (shad) is an anadromous clupeid inhabiting coastal and inshore waters down to about 50 m. It has a maximum length of about 22 cm and a good preference for crustaceans and juvenile fishes. The flat sardine, *Sardinella maderensis*, less abundant than the bonga prefers clear saline and warmer waters with temperature above $24^0$C.

Both the bonga and flat sardines are targets of surface set nets, drift gillnets and encircling or purse seine nets of artisanal fishermen and also by trawlers. Some trawlers in addition to artisanal beach seines and gillnets also exploit shad. Handicapped by weather induced rough seas during the months of June to August, small coastal pelagics support dry season exploitation from mid September to May.

### 3.3 Coastal/inshore demersal finfish fishery

Artisanal bottom set gillnets compete effectively with industrial trawlers in harvesting these coastal demersal resources within the 5–20 m depth. Target species are the *sciaenidae* (Croakers). They are dominated by *Pseudotolithus elongatus* whose bathymetric distribution extends to depths of up to 20 m. They prefer surroundings that are less saline. Commercial concentrations correspond to the estuaries where they are caught in large quantities in certain seasons. They inhabit mud bottoms in depth up to 50 m but also enter estuaries and coastal lagoons. Maximum length is about 45 cm, and moves further offshore to spawn during the rainy season. *P. senegalensis* and *P. typus* are also commonly caught sciaenids. *P. typus* normally attains a maximum length of about 100 cm, but 50 cm sizes are common in the landings. It is the most important sciaenid in Nigerian waters. This species inhabits mud and sandy bottoms and are more abundant in waters of less than 60 m depth and temperature above 18$^0$C. Polynemids, *Galeoides decadactylus*, *Polydactylus quadrifilis*; Bigeye, *Brachydeuterus auritus*; catfish, *Arius* spp; grunters, *Pomadasys* spp; snapper, *Lutjanus dentatus*; groupers, *Epinephelus* spp; sharks; rays and soles *Cynoglossus* spp. are also targets of fish trawl operators.

## 3.4 Coastal/inshore demersal shrimp fishery

The marine environment off the Niger Delta comes strongly under the influence of the Inter Tropical Continuity Zone (ITCZ) and its associated trade winds. The annual shift of the ITCZ brings heavy rain to the Delta area between April and October. The resulting heavy load of rich organic debris brought down by various rivers on the delta supports rich shrimp resources. *Penaeid* shrimp resources are concentrated in the Niger-Delta due to the broad continental shelf and the various outlets to the sea that allow movement of juvenile shrimp between the sea and the brackish waters favourable for its life cycle. Shrimp grounds cover about 2 500 m$^2$ off Nigeria. Shrimp stocks are found in abundance off Badagry to Lagos, Lekki Lagoon system and mouths of rivers on the Delta from River Benin to Pennington and from River Bonny to the Cross River estuary.

The species mostly exploited are the Pink shrimp, *Penaeus notialis*, which is most abundant and most valued economically; Guinea shrimp, *Parapenaeopsis atlantica*; Tiger Shrimp, *Penaeus kerathurus* and the Royal shrimp, *Parapenaeus longirostris*. *P. notialis* prefers the supra-thermocline muddy sand with fine particles and abundant organic matters at 25$^0$C and 35 percent. Concentrations are particularly high in the Niger Delta at 20-30 m. *Parapenaeopsis atlantica* is prevalent at 10-40 m depth while *Parapenaeus longirostris* is found in deep waters from 60–400 m. Exclusively exploited by small scale operators with passive cane or netting gear in the estuary and with small trawls in the surf zones, the white shrimp *Nematopaleamon hastatus,* a major shrimp fishery is heavily fished in the creeks and limited to depths up to about 50 m. It constitutes about 50 percent in terms of estuarine catches. Also harvested by artisanal fishermen are the brackish water prawn (*Macrobrachium macrobrachion)*, river prawn (*Macrobrachium vollenhovenii)* and juvenile pink shrimp (*Penaeus notialis = Penaeus duorarum*).

The shrimp season in the estuaries is during the dry season between November and May. At sea, it is all year round with peaks during the rains from May to September. The periods between August and September and February to March during which the juveniles are in the creeks and lagoons correspond with the period of low catch rates.

## 3.5 Offshore pelagic fishery

Tuna and tuna-like fishes are the most important pelagic resources in the offshore waters of Nigeria. The targets of the offshore pelagic fishery include Skipjack tuna *(Katsuwonus pelamis*), Yellow fin tuna (*Thunnus albacares*) and big eye (*Thunnus obesus*). Tuna-like fishes also targeted include *Euthynnus alleteratus*, *Sarda sarda* and *Elagatis bipinnulata*.

### 3.6 Offshore demersal fishery

The fishery of this zone includes fish species like *Priacanthidae, Sparidae, Aromidae* and shrimps. *Pentheroscion mbizi* is also abundant within the 50 and 100 m depth. The offshore demersal fishery, which consists mainly of small fishes less than 30 cm total length, is still largely unexploited.

## 4. POTENTIAL YIELD

### 4.1 Coastal inshore artisanal fisheries

FAO conducted a comprehensive statistical survey of the coastal and estuarine fisheries of Nigeria west of the Niger (Lagos, Ogun, Ondo and Delta States) between 1965 and 1968. The survey traversed about 4 000 miles with visits to over 300 fishing villages and 600 landing sites. Of the 91 203 fishermen estimated, 54.32 percent (i.e. 49 541) were full time. The number of fishing villages and the area of the coastal and estuarine waters of the then Rivers and Cross River States were more than double the western and mid-western survey area (Ssentongo *et al.*, 1983). With this, the number of full time fishermen was put at about 149 000. These figures have been largely influenced upwards over the years due to lack of job opportunities for young school leavers and provision of better socio-economic and educational facilities in the various fishing villages and landing sites.

A mean of 0.95 tonnes per man-year was calculated for full time fishermen while part timers who do only subsistence fishing was calculated on 20 percent of the full time catches. Based on these calculations, full time fishermen were estimated to produce about 141 550 tonnes while part timers produced 28 310 tonnes. The coastal artisanal and estuarine yield was consequently expected to be about 169 860 tonnes.

Tobor and Dublin-Green (1992) estimated there to be 308 740 artisanal fishermen. According to the Federal Department of Fisheries, freshwater fishermen account for 33.3 percent, and 45.68 percent are part-timers. Given this, the number of full time coastal and brackish water artisanal fishermen was calculated to be 308 740 x 0.67 x 0.5432 = 112 364. Assuming 0.95 tonnes per fisherman per year, the annual fish landing was estimated to be 106 746 tonnes. The total annual production figures sum up to 128 095.2 tonnes if the 20 percent production of the part timers is included. This led to the conclusion that the yield of the coastal and brackish water artisanal fisheries ranges between 128 000 and 170 000 tonnes.

Summing up the production of Western (Lagos, Ogun and Ondo States) and Mid-Western (Bendel State) Nigeria as 60 286 tonnes, and assuming identical production rate west and east of the delta, Ajayi and Adebolu (in press) predicted 100 000 tonnes as the potential of the fin fish fishery. They further estimated a potential of 25 000 tonnes for *Nematopalaemon hastatus* using reported trap catch rates, thereby bringing the coastal and brackish water artisanal fishery potential to 125 000 tonnes which agrees with the range 128 000 – 170 000 tonnes. In contrast, Ssentongo *et al.* (1983) estimated 190 000 mt as the resource potential.

## 4.2 Inshore trawl fisheries

### *4.2.1 Shellfish fishery*

Ajayi (1982), analysing the 1971-1978 catch and effort data of Nigerian shrimpers using the exponential model, calculated a sustainable yield of 2 008 tonnes for 12 651 days at sea. Ajayi and Adebolu (pers. Comm.), combining shrimp catch data from Cameroonian shrimpers with Nigerian fishing trawlers and shrimpers estimated MSY ranging from 3 250 – 4 000 tonnes. Pooling all the estimates, the potential of the Nigerian inshore shrimp resources is put at between 3 250 – 4 016 tonnes.

### *4.2.2 Fin fish fishery*

The 1965-1972 trawl catch and effort data analyzed by Ajayi (1982) using the Fox (1970) exponential model gave an annual MSY of 132 742 tonnes for the inshore trawl fishery. In contrast, Ajayi and Talabi (1984) estimated that the potential of the inshore industrial fin fish fishery using 52 mm cod end mesh ranges between 9 048 and 16 965 metric tonnes. If the 52 mm meshes are replaced by the 76 mm cod end meshes now legal for finfish, a potential of about 20 000 tonnes is possible (Ajayi and Talabi, 1984). The estimated contribution of shrimpers' by-catch to the inshore fish potential is conservatively put at 6 150 – 7 380 tonnes. When the 20 000 tonnes potential possible from the use of 76 mm cod-end meshes is added to the 7 500 tonnes shrimpers' by-catch, the total finfish potential in the 5 – 100 m depth is about 27 500 tonnes.

## 4.3 Offshore fishery

### *4.3.1 Demersal*

Tobor (1990) reported an average estimate of 6 370 mt as the potential yield of Nigeria's offshore demersal resources. Earlier results from the Guinea Trawl Survey (GTS) estimated approximately 31 000 tonnes as the standing stock within the 50–200 m depth area. The potential of the offshore Royal shrimp, *Parapenaeus longirostris*, which occurs in this zone from 50–200 m depth, is yet to be determined. Indications are that this is large, and that fishermen only exploit the outer fringes of its distribution.

### *4.3.2 Pelagic*

Early estimates suggested a standing stock of 44 600 tonnes, with a potential yield of 8 920 tonnes. The 1982-1983 pole and line tuna survey conducted by the Nigerian Institute for Oceanography and Marine Research (NIOMR) which averaged 76 tonnes per 30-day trip confirms the potential estimate. Like the demersal resources, and despite the advantageous location relative to the tuna resource and rich endowment, offshore pelagic resources remain largely unexploited.

## 4.4 Total potential yields

Akande (1993) and Ajayi (unpublished) examined the demersal and pelagic fish as well as the shellfish components of artisanal catches. Using the number of fishermen and gear, catch per fishermen day, and area of the fishing grounds, he estimated the potential yields of the demersal, pelagic fish and shellfish components as 20 000 – 24 000, 120 000, and 48 000 mt respectively, giving a maximum of 192 000 mt. The distribution of the resource based on the potential yields estimated above is illustrated in Figure 1.

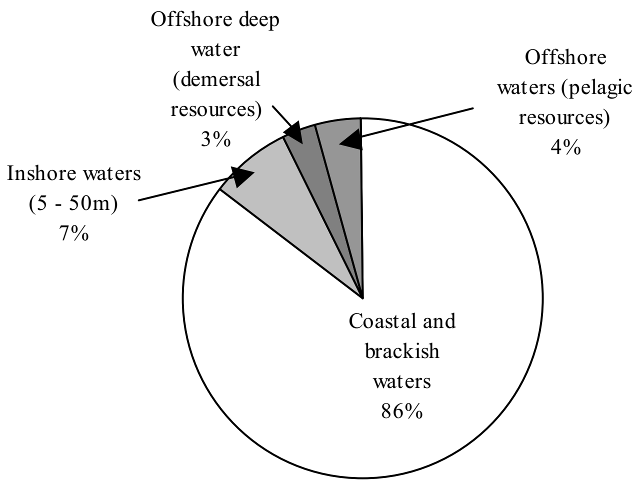


**Figure 1. Distribution of potentials yields in marine waters of Nigeria**

## 5. FISH PRODUCTION

### 5.1 Artisanal coastal/inshore production

The marine coastal artisanal fishery constitutes the most important component of the fishery sector, as it is the highest contributor to the total fish production in Nigeria. The fishery is either non-motorized whereby fishing is done not too far from shore, or motorized with out-board or in-board motors fitted to canoes thereby enabling movement farther out to sea (Table 1). Fishermen operating in this sector employ mainly large motorized Ghana-type canoes and operate mostly in waters less than 40 m depth. In 1976, 413 832 fishermen employing 134 337 canoes out of which 8.71 percent was motorized produced 327 561 mt of fish. Production increased in 1977 and 1978 due to the increase in both the numbers of canoes and fishermen. Highest production ever from this sub-sector was in 1982 when 105 239 canoes with 18.6 percent rate of motorization were used by 416 959 fishermen to produce 377 683 mt of fish.

This increase was as a result of the Agricultural policy of the then civilian administration that encouraged the provision of fishing inputs including out board engines to registered Fishermen Co-operative Societies at 50 percent subsidy from 1979 to 1983. The drastic fall in production in 1984 was as a result of the difficulties in supplying fuel and lubricants to the fishing villages due to the then Government's policy on fuel distribution and supply which made it difficult for fishermen to source fuel with which to operate their engines. Lowest production during the period was recorded in 1993 when 106 276 mt of fish were landed by 456 381 fishermen using 77 050 canoes of which 20.82 percent was motorized. This reduction is attributable to the reduction in the number of available crafts, since the number of fishermen remained rather stable.

*Table 1. Coastal artisanal fish production 1976 - 1994*

| Year | No. of Canoes | % Motor-isation | Part-time Fishermen | Full-time Fishermen | Total No. Fishermen | Fish Production (mt) |
|---|---|---|---|---|---|---|
| 1976 | 134 337 | 8.71 | 124 140 | 289 682 | 413 832 | 327 561 |
| 1977 | 137 447 | 8.87 | 127 421 | 297 317 | 424 838 | 331 280 |
| 1978 | 138 247 | 7.32 | 121 989 | 293309 | 425 298 | 336 138 |
| 1979 | 133 728 | 9.35 | 133 846 | 312,306 | 446 152 | 356 888 |
| 1980 | 133 723 | 9.87 | 146 605 | 312,460 | 459 065 | 274 158 |
| 1981 | 120 142 | 15.5 | 160 052 | 280 540 | 440 592 | 323 916 |
| 1982 | 105 239 | 18.6 | 176 057 | 240 902 | 416 959 | 377 683 |
| 1983 | 129 555 | 18.4 | 272 773 | 199 349 | 472 122 | 376 984 |
| 1984 | 109 638 | 22.86 | 197 720 | 144 499 | 342 219 | 246 784 |
| 1985 | 80 688 | 24.55 | 127 615 | 174 619 | 302 234 | 140 873 |
| 1986 | 77 134 | 20.75 | 171 517 | 237 455 | 408 927 | 160 169 |
| 1987 | 76 644 | 21.04 | 184 754 | 252 711 | 437 465 | 145 755 |
| 1988 | 77 144 | 20.76 | 188 767 | 259 083 | 447 850 | 185 181 |
| 1989 | 77 155 | 20.76 | 198 188 | 272 062 | 470 250 | 171 332 |
| 1990 | 76 981 | 20.38 | 190 900 | 261 287 | 452 187 | 170 459 |
| 1991 | 77 093 | 20.79 | 192 958 | 264 144 | 457 102 | 168 211 |
| 1992 | 77 076 | 20.81 | 194 016 | 265 831 | 459 847 | 184 407 |
| 1993 | 77 050 | 20.82 | 192 624 | 263 757 | 456 381 | 106 276 |
| 1994 | 77 073 | 20.8 | 193 198 | 264 577 | 457 775 | 124 117 |

Source: Federal Dept. of Fisheries (1995)

## 5.2 Trawl fisheries production

The inshore sub-sector is the most productive and intensely exploited zone of the Nigerian continental shelf. Trawlers used in exploiting the inshore waters increased from 149 in 1985 to 304 in 1994 (Table 2).

*Table 2. Licensed inshore trawlers and their total fish and shrimp landings - 1985 – 1994*

| Year | Registered Vessels | | | Landings (tonnes) | | |
|---|---|---|---|---|---|---|
| | Fishing | Shrimping | Total | Fish | Shrimps | Total |
| 1985 | 109 | 40 | 149 | 23 766 | 2 376 | 26 142 |
| 1986 | 137 | 54 | 191 | 22 419 | 2 623 | 25 042 |
| 1987 | 161 | 82 | 243 | 21 383 | 3 517 | 24 900 |
| 1988 | 161 | 132 | 293 | 32 740 | 2 868 | 35 608 |
| 1989 | 134 | 158 | 292 | 28 411 | 5 234 | 33 645 |
| 1990 | 123 | 195 | 318 | 21 120 | 3 666 | 24 786 |
| 1991 | 102 | 195 | 297 | 28 768 | 6 200 | 34 968 |
| 1992 | 75 | 203 | 278 | 25 592 | 9 373 | 34 965 |
| 1993 | 83 | 223 | 306 | 22 464 | 8 956 | 31 420 |
| 1994 | 74 | 230 | 304 | 21 886 | 7 884 | 29 770 |

Source: Federal Dept. of Fisheries (1995)

These trawlers range between 50 and 200 Gross Registered Tonnage (GRT), but most of them fall within the 100-150 range. More than 50 percent of these vessels have GRT higher than the approved maximum (130 GRT). This is because vessels licensed prior to the promulgation of the Sea Fisheries Decree and Regulations were allowed to remain in use. Recent fisheries regulations provide that fish trawls carry 76 mm stretched cod-end mesh sizes while shrimp trawls are permitted to carry trawl cod-end with 44 mm stretched mesh sizes. The capacity of the vessels' main engines varies between 165 and 800 HP. Although no limitation is placed on fishing/shrimping vessels' engine capacity by law, more than 55 percent of shrimp vessels are fitted with engines of between 500–550 HP. The average cruising speed of most of the vessels is about 11 knots per hour while the trawling speed is three knots. Fish finding equipment on the vessels is mainly the echo sounder. Catch is preserved in fish-holds usually between 40–50 mt capacity maintained at a temperature of $35^0$C. Most shrimp vessels in addition are fitted with plate freezers capable of quick freezing 0.5 tonnes of shrimps packaged at sea/hour.

The history of a serious private sector led trawl fisheries initiative in Nigeria started in 1982 with the introduction of 49 medium size TR-13 trawlers allocated to registered Fishermen Co-operative Societies into the inshore fishery. However, tremendous growth in trawl fishing was witnessed in 1985 with the deployment of 149 fishing and shrimping vessels, harvesting a total of 23 766 mt of fish and 2 376 mt of shrimp. The number of licensed vessels increased to 191 in 1986 producing 22 419 mt of fish and 2 623 mt of shrimp. Though the number of vessels increased to 243 in 1987, fish production dropped to 21 383 mt while shrimp production increased to 3 517 mt. In 1989, number of fishing vessels dropped to 134, a reduction by 16.8 percent, from the 161 operated in 1988 while shrimpers increased to 158, a percentage increase of 19.7 percent. During this year, fish production reduced by 13.2 percent to 28 411 mt while shrimp production rose by 82.5 percent to 5 234 mt. As from 1989, the number of vessels licensed for shrimping within the inshore zone outnumbered those licensed for fishing, and the trend has since been sustained. Fish production figures started to slide as from 1991 while that of shrimps remained relatively high probably due to the increasing number of vessels licensed for its harvesting. Table 3 presents the number of vessels licensed for inshore operations and their total production figures from 1985 to 1994.

## 6. ASSESSMENT OF FISHING CAPACITY IN THE NIGERIAN FISHERY

### 6.1 Artisanal sector

From Table 1, the maximum sustainable yield for the coastal inshore pelagic resources, estimated at around 190 000 mt, was exceeded in the period between 1976 and 1984 when production figures ranged between 246 784 and 377 683 mt. During this period, the lowest number of canoes deployed was 105 239 while the highest was 138 247. With 342 219 fishermen in 1984 using the lowest number of canoes during the period, production still exceeded the MSY for the fishery. The lowest fishing capacity of 105 239 canoes in 1982 yielded the highest production figure during the entire period covered. In 1985, when the number of canoes went down by 26.40 percent to 80 688 with 24.55 percent motorization and 302 234 fishermen engaged, production went down by 42.92 percent to 140 873 mt from 246 784 mt produced the previous year. However, from 1985 to 1994, despite the relatively stable number of fishermen involved production from the sector dropped, probably due to the drastic reduction in the number of canoes and fishing effort applied. Production during this period fell to levels below the MSY.

The ratio of canoe to fishermen between 1976-1980 was 1:3 (Table 3), during which average annual production per fisherman was 792 kg. The ratio went up to 1:4 between 1981 and 1983 without any drop in average productivity. However, during the period 1987 to 1994, the ratio increased to 1:6 and productivity dropped to an all time low of 233 kg per fisherman in 1993. The reason that could be adduced is that the ratio of one canoe to six fishermen was too high and constituted a waste of available labour and manpower resources. A safe conclusion is that the fall in production was a factor of the reducing number of crafts available to the fishery, as such; the number of crafts should be increased to a level that will sustain the canoe/fishermen ratio at 1:3 to generate higher productivity. More motorized canoes must, therefore, be made available to the artisanal fishermen most probably at the 1982 level to achieve this objective, as available data indicate that the stock is still able to absorb more fishing effort and capacity without adverse effects on the resource.

*Table 3. Artisanal fisheries productivity assessment - 1976-1994*

| Year | No. of canoes | Total No. fishermen | Fish (mt) production | Fishermen/ canoe | Productivity kg/canoe/year | Productivity kg/fisherman/ year |
|---|---|---|---|---|---|---|
| 1976 | 134 337 | 413 832 | 327 561 | 3 | 2 438 | 792 |
| 1977 | 137 447 | 424 838 | 331 280 | 3 | 2 410 | 779 |
| 1978 | 138 247 | 425 298 | 336 138 | 3 | 2 431 | 790 |
| 1979 | 133 728 | 446 152 | 356 888 | 3 | 2 669 | 799 |
| 1980 | 133 723 | 459 065 | 274158 | 3 | 2 050 | 597 |
| 1981 | 120 142 | 440 592 | 323 916 | 4 | 2 696 | 735 |
| 1982 | 105 239 | 416 959 | 377 683 | 4 | 3 589 | 906 |
| 1983 | 129 555 | 472 122 | 376 984 | 4 | 2 910 | 798 |
| 1984 | 109 638 | 342 219 | 246 784 | 3 | 2 251 | 721 |
| 1985 | 80 688 | 302 234 | 140 873 | 4 | 1 746 | 466 |
| 1986 | 77 134 | 408 927 | 160 169 | 5 | 2 077 | 392 |
| 1987 | 76 644 | 437 465 | 145 755 | 6 | 1 902 | 333 |
| 1988 | 77 144 | 447 850 | 185 181 | 6 | 2 400 | 413 |
| 1989 | 77 155 | 470 250 | 171 332 | 6 | 2 221 | 364 |
| 1990 | 76 981 | 452 187 | 170 459 | 6 | 2 214 | 376 |
| 1991 | 77 093 | 457 102 | 168 211 | 6 | 2 182 | 368 |
| 1992 | 77 076 | 459 847 | 184 407 | 6 | 2 393 | 401 |
| 1993 | 77 050 | 456 381 | 106 276 | 6 | 1 379 | 233 |
| 1994 | 77 073 | 457 775 | 124 117 | 6 | 1 610 | 271 |

The main reason attributable to the fall in the number of canoes, both motorized and non-motorized, was the rise in the cost of fishing inputs. This was occasioned by the withdrawal of the 50 percent subsidy on fishing inputs hitherto given by Government and the fall in the value of the Nigerian currency due to the global economic recession, which made the prices of imported items including fishing inputs prohibitive. Fishermen who are mainly rural based lack collateral, and credit facilities were not readily available to enable them procure the inputs at the prevailing market prices.

## 6.2 Inshore trawl fisheries

The available data (Table 2) indicate that the MSY of 27 500 mt for fish (Ajayi and Talabi, 1984) and between 3 250 and 4 016 mt for shrimp resources (Adetayo, 1982; Ajayi, 1982) was exceeded in 1988, 1989 and 1991. The data also indicate that the number of vessels licensed for fishing has consistently fallen since 1988 in favour of shrimp vessels to the extent that only 74 vessels out of 304 were licensed for shrimping which by law are allowed to carry trawls with 44 mm cod-end meshes. The 20 000 mt MSY for the finfish fishery calculated on 76 mm cod-end mesh trawls is therefore unattainable under the circumstance. Accordingly, catch has continued to be in excess of the MSY for the finfish resources till date. This is probably responsible for the noticeable decline in the size and quality of fish landed since 1991.

An early estimate of the capacity fleet size suggested that the 10 000 tonnes demersal finfish potential is only able to support 40 trawlers, operating at between 240-250 days per year, with an average catch of approximately 1.0 mt per day. Using this estimation, the daily CPUE for fish for the period 1985-1994 is as contained on Table 4. A logical deduction is that vessels during the period covered, operated at CPUE lower than earlier estimated by

Longhurst. This is an indication of excess fishing capacity between 1986 and 1991. Hence, the CPUE did not increase even when the capacity went down to 75 vessels from 102 in 1992. Using the earlier assumption of an average catch of 1.0 mt of fish per vessel at between 240–250 days/year operation, a realistic capacity required to sustainably harvest the 16 620 mt potential (Tobor, 1990) inshore fin fish fishery would therefore be 65 vessels.

*Table 4. Production of inshore fishing vessels licensed from 1985 to 1994*

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|
| Vessels | 109 | 137 | 161 | 161 | 134 | 123 | 102 | 75 | 83 | 74 |
| Fish | 20 658 | 19 452 | 16 632 | 25 826 | 16 793 | 10 786 | 10 921 | 6 300 | 4 292 | 5 493 |
| Shrimp | 1 016 | 1 549 | 2 298 | 1 168 | 1 454 | 786 | 1 248 | 1 270 | 761 | 639 |
| Fish cpue/day | .790 | .592 | .430 | .668 | .520 | .365 | .446 | .350 | .215 | .309 |

Adapted from Federal Department of Fisheries (1995)

Between 1989 and 1990, the recorded annual shrimp catch was more or less close to the maximum potential available to Nigeria. Effort on the other hand continued to rise. This resulted in a decline in shrimp catch per unit effort and a corresponding increase in incidental fish catch. Apparently in response to the declining shrimp CPUE, shrimp trawl operators resorted to using 32–35 mm cod-end meshes in violation of existing regulations. Figures for shrimp landings both published and unpublished MCS data confirm that production has been in excess of the MSY for the shrimp fishery. Daily CPUE for shrimpers according to MCS records from 1996 to 1998 has been between 150–170 kg even when the number of days fished per year is less than 180. This is indicative of excess effort, which may culminate in serious resource depletion if the trend is not checked. In order to redress the situation, an assessment of the capacity required to sustainably harvest the shrimp fishery producing 250 kgs at an effort of 240 days per year is estimated at between 54 and 70 vessels (Table 5).

*Table 5. Estimates of the number of vessels the Nigerian shrimp potential of 3,250 - 4,016 tonnes can support annually*

| | Potential range of(m.t.) | | | |
|---|---|---|---|---|
| | 3 250 – 4 016 | 3 250 – 4 016 | 3 250 – 4 016 | 3 250 – 4 016 |
| Shrimp catch rate kg/day at sea | 250 | 270 | 300 | 330 |
| Total effort (days at sea) | 13 000 – 16 064 | 12 037 – 14 874 | 10 833 – 13 387 | 9 848 – 12 170 |
| No. of vessels required. at 250 kg/day /vessel/yr. | 52 - 64 | 48 - 59 | 43 - 54 | 39 - 49 |
| No. of vessels required. at 300 kg/day /vessel/yr. | 43 - 54 | 40 - 50 | 36 - 45 | 32 - 41 |

Source: Ajayi and Talabi (1984)

## 6.3 Offshore resources

Estimated potentials of the demersal and pelagic resources of Nigerian offshore waters are put at between 6 370 mt and 8 920 mt (Tobor, 1990). Both the demersal and pelagic resources have remained largely unexploited.

Presently, efforts are being vigorously pursued to encourage investment in the sub-sector to boost local fish supply and foreign exchange earnings through exportation of processed and canned tuna fish.

## 7. REGULATION OF EFFORT AND FISHING CAPACITY

The commercial fishing fleet has the tendency to expand beyond the level required to harvest the available resources, since valuable fish stocks are capable of yielding harvests of greater value than the cost of harvesting. The accruing resource rent, however, varies among fisheries. Since the stock is being harvested as a common property by the fishing enterprises, the resource rent induces them to expand their fishing capacity, even beyond the level required to efficiently harvest the resource. In the absence of any intervention towards preventing or limiting this tendency, the potential resource rent becomes dissipated with time through overcapitalization and high costs in employing labour just as the situation was between 1987 and 1994 in the artisanal sub-sector. If this process is left unchecked, it will result in wasteful expansion of fishing power and resource depletion.

Various regulatory steps have continued to be taken by the Federal Department of Fisheries responsible for the management of Nigeria's fisheries resources to control fishing effort and expansion of fishing capacity in order to ensure sustainable exploitation of its marine fisheries resource. However, since a successful programme of fisheries rationalization must be gradually implemented, and with minimal disruption of established interests, the measures adopted have been subjected to modification and elaboration as the regulatory programmes evolve over time based on the conditions of the resource.

Fishing capacity in Nigeria's multi species fishery has expanded sufficiently to fully exploit the inshore demersal resources. The inshore pelagic resources are still capable of yielding increased harvests while the offshore fisheries resources, both pelagic and demersal, are largely unexploited, and as such able to accommodate reasonable level of fishing capacity. Accordingly, fisheries development policy is directed towards preventing expansion of sectors in which capacity is already sufficient and extending fleet range. To this extent, the first all embracing Sea Fisheries Decree (No. 30) was promulgated in 1971. The Fishing and Licensing Regulations of the Decree were enacted in 1972. Following lapses observed in the effectiveness of this Decree over time, it was repealed and replaced by the Sea Fisheries Decree No. 71 of 1992. The main Decree contained general provisions for the conditions relating to the issuance of fishing and shrimping licences, vessel operations, duties and powers of Authorized Persons and penalties for offences committed. The Sea Fisheries (Fishing and Licensing) Regulations enacted under the new Decree contained provisions almost similar to those of the repealed Sea Fisheries (Fishing and Licensing) Regulations of Decree No. 30 of 1971. However, it provided for wider and stiffer penalties for offenders, extended the non-trawling zone from two to five nautical miles and lifted the embargo on fishing within the Lagos West fishing grounds.

Though many measures could be adopted to regulate the fisheries, every instrument of control has to be considered on its own merit as it is targeted at solving specific problems. Such regulatory problems include regulating the catch composition, regulating the size of the catch, efficient and effective distribution of effort among the various fisheries, preventing monopolistic tendencies and practices, and maintenance of efficiency in the fishing process.

Having identified most of the problems of Nigeria's marine fisheries, various control measures are being adopted to rationalize the efforts and capacity employed in harvesting them.

## 7.1 Restriction on fishing gear

It has been recognized that restriction on fishing gears serves a useful purpose in increasing yields by influencing the composition and quality of the catch. It is also a means of controlling the total catch or the total fishing effort. Accordingly, a stretched cod-end mesh size of 76 mm for fishing trawls and 44 mm for shrimp trawls have been specified for all affected vessels operating within Nigeria's maritime waters. This is to improve the composition of catch and prevent destructive fishing by trawlers. The measure is expected to allow the escapement of juvenile shrimp and fishes. Apart from this, enforcement of the cod-end mesh specification will result into a corresponding increase in the age and mean weight of the shrimp and fish caught by trawlers. Consequently, the gain in value (i.e. catch of large shrimp and fish) would be proportionally more important than the gain in tonnage. The heterogeneity of species of different sizes poses a problem in the use of the specified cod-end mesh sizes, as it will over protect fish of small sizes.

## 7.2 Restriction on fishing areas/closed areas

The Sea Fisheries (Fishing) Regulations of 1972 prohibited trawl fishing within the first two nautical miles of the waters of Nigeria's continental shelf. The area covered by this prohibition is referred to as the 'non-trawling zone'. This zone was further extended to five nautical miles by the 1992 Sea Fisheries Decree Fishing Regulations. Conflicts among different types of gears have led to serious confrontation between trawler operators and artisanal fishermen within this area. This measure, therefore, gives artisanal fishermen exclusive rights to operate without molestation by trawlers within this zone.

Shrimp trawling was prohibited in the inshore waters of the Lagos West fishing grounds in 1972. Such control serves a valuable purpose in protecting stocks from destructive fishing by trawlers thereby improving the value and productivity of the resource. This prohibition order was lifted in 1992 after Government ensured that the fishing ground had sufficiently recovered.

## 7.3 Vessel licensing

In order to control expansion of fleet capacity, fishing vessels are required by law to be licensed before they are allowed to operate within Nigeria's territorial waters and the Exclusive Economic Zone. Before a new vessel is licensed, the intending operator (applicant) must have obtained a Letter of Pre-purchase Assurance from the Director of the Federal Department of Fisheries that the proposed vessel would be granted a licence if procured. The applicant shall be required to submit an application supported by a feasibility report on the proposed fishing venture; specifications of the proposed vessel including tonnage, length over-all (LOA), year of construction and horse power; and a letter of support for fishing in foreign waters, among others. Existing vessels are also required by law to apply for and be issued with current licences before they can operate. The validity of a licence is for a period of one year, starting from January to December. All licences should be renewed at the end of the month of December of every year. The Minister of Agriculture and Rural Development who is the Licensing Officer, has powers to refuse to issue a vessel with a licence without appropriating any reasons for so doing. A licence may also be suspended or withdrawn if the owner is found guilty of infractions of fishing regulations.

Fees charged for the issuance of licences were recently increased. In 1996, licensing fee for shrimp and fishing vessels was N4 000:00 and N3 000:00 respectively. These fees were harmonized and increased to N120 000:00 with effect from January 1999, irrespective of whether the vessel is employed for shrimping or fishing. The fees provide Government with the opportunity to share the value of the resource rent without adversely affecting the incomes of the vessel operators.

Vessels intended for fishing in Nigeria's territorial waters shall not exceed 25.3 m LOA and 150 gross tonnage while shrimp vessels shall not be more than 23.2 m LOA and 130 gross tonnage. These requirements apply to all new vessels, but vessels existing before the regulations came into effect are allowed to remain until they are retired.

Licences are not transferable in Nigeria. In the case of a vessel transferred to a new owner, a deletion certificate shall be caused to be issued by the Inspector of Shipping in the Federal Ministry of Transport where vessels are normally registered. The new owner shall thereafter apply to the Federal Minister of Agriculture and Rural Development for a licence, subject to the same conditions prescribed for new vessels. A licence issued for fishing is not valid for shrimping and vice versa.

According to the Inland Fisheries Decree No. 108 of 1992, artisanal fishing canoes must also be registered and licensed by the Ministry responsible for Fisheries matters in the states used as bases by the fishermen before they can operate. This measure is intended to effectively limit the amount of effort and capacity that can be applied to fish in both the inland and inshore waters of Nigeria.

### 7.4 Removal of subsidies

Government, in an effort to stimulate the development of the fisheries sub-sector, adopted various forms of subsidy arrangements of up to 50 percent on all canoes, fishing equipment and spare parts supplied by it to members of registered Fishermen Co-operative Societies up till 1984. This subsidy was withdrawn when Government was satisfied with the level of capacity development in the sub-sector. Fishermen now procure or are supplied with fishing items whenever available at the current market rates.

The supply of Automotive Gas Oil (AGO) at the Rotterdam bunker wire price to trawl fisheries operators has been cancelled. Operators now procure fuel at the normal market rate.

### 7.5 Distribution of fishing effort

The Government has initiated steps towards redistributing fishing capacity and efforts with respect to the potential yields of the different stocks. Transfer of excess fishing efforts from the inshore waters to new grounds is being done by licensing vessels to fish in the Exclusive Economic Zone and in waters of neighbouring coastal States with which Nigeria has Fishing Rights Agreement. Such Agreements have in time been entered into with Equatorial Guinea, Sierra Leone and Angola. Licences issued under these Agreements are valid only over the stocks for which they are issued. This measure is to relieve pressure over the inshore resources that have started to manifest signs of over exploitation.

### 7.6 Consultative arrangements

An elaborate consultative mechanism exists between government and representatives of owners of fishing vessels licensed to operate Nigerian flagged vessels within or outside Nigerian waters. All vessel owners are required to be members of the Nigerian Trawlers Owners' Association (NITOA), an umbrella organization for all fishing trawl operators, and which plays a vital communications role between its members and Government on all issues that affect its members. The Association is usually consulted on all matters that affect its members and suggestions made by it are usually given serious consideration before decisions are taken.

## 8. FISHERIES RESOURCES MONITORING

Once a restrictive licensing system is in place, its effect on the pattern of fleet development and the evolution of the fleet's fishing power should be watched continuously in order to assess the efficacy of the controls and the need for supplementary measures. This implies some form of systematic monitoring as it will be particularly important to identify the form and degree of technological distortions that result from the restrictions and their consequences for the fleet's aggregate capacity and overall behaviour of the resource.

In 1991, the Government of Nigeria established the National Fisheries Resources Monitoring, Control and Surveillance (MCS) Unit in the Federal Department of Fisheries in order to achieve the above objectives. Its mandate is to ensure that adequate data on effort and capacity used in harvesting the nation's fisheries resources are collected and collated for its sustainable management. Other functions of the Unit include Search and Rescue Operations for distressed fishing vessels in collaboration with the Nigerian Navy, Sea patrol and surveillance to ensure compliance with fishing regulations and monitoring of the resource to enable it advise Government on the state of the resource.

## 9. CONCLUSION

Nigeria's marine fisheries resources have undergone considerable development within the last two decades, particularly in the inshore demersal trawl fisheries sub-sector to the extent that production from the sub-sector has in the last few years been consistently higher than the estimated yield. Nigeria's fisheries resources have potentials of withstanding sustained exploitation under effective management. The coastal inshore artisanal fishery is still able to absorb a little more effort and capacity to enable production meet up with the potential yield. Inshore pelagic, offshore demersal and pelagic resources remain largely untapped. Current efforts towards diverting fishing efforts from the coastal inshore demersal operations to deeper waters where the snapper and abyssal fauna are either under exploited or yet to be exploited are desirable for the achievement of sustainable exploitation of the resource.

It is however essential in the national interest that there should be a clear understanding of fishing capacity development on capital, labour and fish resources, both in the short and long term. The choice of the most appropriate combinations is not easy since the benefits, both direct and indirect, will be distributed in different ways. In some cases, the sustenance or increase of the revenue to fishermen and contributions to the economy are paramount. In others, the choice is to develop fisheries as a means for meeting social objectives and increasing the opportunities for employment. Whatever the choice, fishing capacity should be determined and maintained at such a level that exploitation is rational and management sustainable.

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# THE ASSESSMENT OF FISHING CAPACITY IN MAURITANIA

**Chérif Ould Touileb**[1]

**Abstract:** A combined input and output based approach is used to estimate the level of excess capacity in the Mauritanian fisheries. The output of a 'standard' fishing vessel is estimated assuming it is fully utilized. Given this, the number of standard vessels required to take the target catch is estimated. The level of excess capacity is assessed with regard to the difference between the current fleet and the required number of standard vessels. An example is given relating to the cephalopod fishery.

## 1. HISTORICAL BACKGROUND

The fisheries sector plays a leading role in the Mauritanian economy, providing foreign currency, employment and revenue. Fish is also a low cost and sustainable source of animal protein to a growing number of consumers. As such, it plays an important role in food security.

Since the adoption of the New Fisheries Policy (1979), which aimed at incorporating the fisheries sector into the national economy, the fishing industry has undergone a rapid development. The national fleet developed in a precipitated manner in the 1980s, especially in export-based demersal fisheries. In 1999, the fleet was composed of 499 industrial vessels. Of these, 376 units were equipped with on-board freezing capacities, while the remainder (123 trawlers) used ice. In addition to this fleet, the small-scale artisanal fleet also expanded rapidly over the last decade. There were 2 430 artisanal and small-scale boats operating in 1999.

Successive fisheries policy statements adopted by Mauritania stressed the importance of developing high value-added activities, such as on shore processing of fishery products and the development of artisanal fisheries. Artisanal fisheries are labour-intensive and require relatively low levels of technology and investment. Artisanal vessels are as a result quite adequate for the exploitation of coastal resources, which represent in terms of value the most important fishery resources of Mauritania.

The present policy framework, adopted as a "National Fisheries Management and Development Strategy", comes at a key moment in the history of the exploitation of fishery resources – characterized by a gradual decline in fisheries resources and persistent increase in fishing effort, which will, inevitably, lead to a critical situation in terms of resource unsustainability and of reduced financial viability for the industry. The "National Fisheries Management and Development Strategy" recognizes the rapid changes that the fishery sector is currently experiencing at the national and international levels, and emphasizes the necessity to accompany these changes with strengthened management measures.

States are increasingly convinced of the necessity to ensure a sustainable management of the natural resources that fall under their jurisdiction, and of the resources that they share with neighbouring countries. Yet, as a motor in the international scene, the United Nations and its specialized agencies remain the front-runners in the protection of the Oceans and of

[1] Ministry of Fisheries and Maritime Economy, Department of Studies and Fisheries Management, Nouakchott, Mauritania. Email: dearh@mpem.mr

their living resources, two themes which they give top priority to. The United Nations Convention on the Law of the Sea, the Convention on Biodiversity, the Convention on the Protection of Endangered Species and the Code of Conduct for Responsible Fisheries show the commitment of the international community to efficiently manage the marine environment and to exploit marine resources in a sustainable manner, while reducing poverty and supplying fish for food to a world's population whose growing birth rate continues to preoccupy both experts and policy-makers.

In a world of wealth and poverty, mankind has an essential role to play and the effective management of plant and animal production systems is a guarantee to a sustainable exploitation of living resources in harmony with the environment. For resources such as fisheries, irresponsible behaviour can lead to highly unsustainable outcome and the life of present and future generations largely depends on our capacity to regulate our production and consumption patterns.

Among the steps required to manage fisheries, it is essential to control the amount of fishing capacity at national and international levels. In order to regulate fishing capacity, it is also important to define and implement plans for fisheries management and sustainable development with a view to preventing any unnecessary increase in capacity levels and the depletion of fisheries resources. The factors to be considered in Mauritania are twofold.

First are the national fisheries resources that the State manages and for which it is responsible. Access to these resources is the object of much competition. On the one hand, the local industry is affected by diminishing yields and feels threatened by foreign fleets that are sometimes more technologically advanced. On the other hand, foreign fleets operating under access agreements are asking for a greater part of available quotas, if only because of the scarcity of resources in other traditional fishing grounds. Foreign fleets are also struggling against reduced yields (at home and in Mauritania) and access agreements negotiated with Mauritania allows many of the vessels concerned to stay in operation. Access fees and related payments are a very important source of revenue for the country. These represent a significant part of the national budget and a major source of foreign exchange.

Second are the shared resources and international stocks for which management falls under the jurisdiction of several States or international organizations. It is particularly difficult to manage these stocks for the following reasons:

- There is a race amongst States to fish as much as possible, owing to the fact that fish stocks are shared or migratory.
- States do not always have a regional strategy fixing fishing quotas by countries and by species (regional and sub-regional organizations are still weak and have not defined such measures);
- Fisheries research institutions do not have complete and reliable estimates on the status of stocks, especially for stocks for which an assessment methodology has yet to be developed;
- States have not established mechanisms for monitoring stocks and controlling fishing operations;
- Regulations are not harmonized;
- Statistics regarding harvesting potentials, catches, effort and capacity are most often incomplete, erroneous or irregular; and
- Management policies are still lacking both at the national and regional levels.

## 2. FISHERIES RESOURCES IN THE MAURITANIAN EEZ

Mauritania has abundant fisheries resources, and its inshore waters are the cradle of an intense biological activity. These fisheries resources are exploited with increasing intensity, especially as regard high value species. Recent estimates report a fisheries potential of about 1 1 500 000 tonnes per annum, most of which composed of pelagic species. High value species consist in particular of cephalopods, crustaceans and various species of demersal fishes. Theses species represent about 20 percent of total catch. The overall status of exploitation is indicated below for the three main fisheries components.

- Industrial demersal fisheries: the decline in yields is well documented and signs of overexploitation are a growing concern.
- Industrial pelagic fisheries: resources are moderately exploited; possibilities exist for increased exploitation and improved creation of value-added.
- Coastal and artisanal fisheries: some resources are still available for further development.

## 3. DESCRIPTION OF SYSTEMS OF EXPLOITATION

A diversity of vessels operates on the Mauritanian EEZ. The main types of vessels are: pelagic freezer trawlers; bottom freezer trawlers; bottom ice trawlers; lobster boats; shrimp trawlers; small decked vessels; and small open boats. The national freezer fleet is 18 years old on average. Ice trawlers have been introduced quite recently. Following the depletion of sparids stocks, the exploitation of demersal fisheries has since focused on cephalopods and, in particular, on octopus.

The authorized global fishing capacity amounted to 499 vessels in 1999. In addition to this fleet, there are 2450 artisanal and small boats (the capacity of a small boat is estimated at 1 GRT). The composition of vessels and the global fishing capacity in Mauritania is shown in Table 1.

*Table 1: GRT units, fishing days and boas number by fishery*

| | GRT units | Fishing days | Number of boats | Average number of days at sea per year |
|---|---|---|---|---|
| Freezer trawlers | 501 031 | 32 854 | 376 | 87 |
| Ice trawlers | 26 219 | 13 161 | 123 | 107 |
| Small boats and small decked vessels | 2 450 | 627 400 | 2 450 | 252 |
| Total | 529 700 | 663 415 | 2 949 | 446 |

## 4. MEASUREMENT OF FISHING CAPACITY

### 4.1 Assessment

The national centre for marine research and fisheries (*Centre National de Recherche Océanographique et des Pêches* – CNROP) has organized a series of assessments of fisheries resources, leading to an estimation of corresponding allowable fishing effort (capacity). Following the 1988 assessments, the 1993 working group reviewed the status of fisheries resources and provided for a description of the fleets. The first estimates of allowable fishing effort by main fishery were derived on this basis. The last working group met in December 1998.

Even though these findings provide for a clear overview of the measurement of fishing capacity, it is important to further consider the multispecific nature of main fisheries and the heterogeneity of the fleet.

Applying measures of fishing capacity to the management of specific multispecies fisheries is only relevant if the characteristics of fisheries and fleets interactions are duly considered. This implies an explicit recognition that fishing effort entails catches of species other than the one(s) targeted in a main fishery, including species that are targeted or harvested in significant amounts in other main fisheries.

If the resource is composed of several fished species, target fishing effort cannot be estimated based on summing up the potential output of each species. Fishing effort is considered to be equally applied across all the different species caught in a main fishery. Target fishing effort is further defined on the basis of the maximum potential output of one single species identified as reference amongst all. The choice of a reference species depends on its state of exploitation, its economic importance and other specific factors. Reference species used for this purpose are the following: octopus, sparids, hakes, shrimp, horse mackerel, clams, crabs, and pink lobsters (see Table 2b, second column).

On this basis, capacity can be measured and assessed for each main fisheries (e.g. octopus as reference species for the main fishery of cephalopods, etc). Capacity is measured on the basis of inputs: the number of vessel units operating in the fishery, gross registered tonnage and days at sea.

## 4.2 Approach to the measurement of fishing capacity

The approach may be summarized as follows:

- identify main fisheries and fishing units operating in these fisheries;
- choose a reference species as a unit for the management of a main fishery and estimate its potential or target production;
- estimate actual catch, effort and fleet size in main fishery and for the reference species in particular;
- quantify the impact of harvesting the reference species on other species and fisheries with which they interact;
- standardize vessels and estimate the average number of days at sea achieved under normal conditions for each standard vessel;
- define conversion factors between the different fleets within the same fishery;
- estimate actual global effort in number of fishing days by main fisheries;
- estimate target global effort and corresponding standard fleet size by main fisheries, in relation to the potential output of the reference species.

The following application is used for estimating fishing capacity in relation to the state of the cephalopods fisheries.

*Table 2(a). Characteristics of vessel's units*

| | GRT | Engine Power | Length |
|---|---|---|---|
| Cephalopod Freezer trawlers | 295 | 851 | 37 |
| Ice trawlers | 91 | 310 | 20 |
| RTMS* | 3019 | 3880 | 102 |
| Hake trawlers | 320 | | |
| Shrimp trawlers | 225 | | |

* RTMS, RTMA and BMRT refer to Russian types of vessels

*Table 2(b). Recapitulation of all findings*

| Fisheries | Reference Species | Allocated Potential by Fishery | Standard unit (vessel) | Average number of fishing days a year | Standard CPUE per fishing days in tonnes | Allocated Effort: Unit's number of fishing days/ year | Allocated Effort: number of vessel's units/year | Allocated Effort: GRT/year |
|---|---|---|---|---|---|---|---|---|
| Cephalopod Trawlers | Octopuses | 32 416 | Freezer trawler | 289 | 1.42 | 22 827 | 79 | 23 305 |
| National Ice Trawlers | Sparids | 8 846 | Ice trawler | 192 | 0.52 | 17 012 | 88 | 8 008 |
| Hake Trawlers | Hakes | 11 113 | Hake trawler | 135 | 2.46 | 4 517 | 33 | 10 560 |
| Shrimp Trawlers | Shrimp | 750 | Shrimp trawler | 282 | 0.09 | 8 333 | 30 | 6 750 |
| Small Pelagic Trawlers | T. trecas | 220 000 | RTMS* | 220 | 18.68 | 11 777 | 53 | 160 000 |
| Unexploited Resource | Clams | 301 000 | Drag nets | | | | | |
| Unexploited Resource | Crabs | 94 | Pots/Traps | | | | | |
| Unexploited Resource | Pink lobsters | 800 | Pots/Traps | | | | | |

**Allocation of effort amongst fishing vessels**

- Cephalopods: Ng*0.67 + Nc*1= 79 vessels
- Small Pelagics*: Nrtm*1 +Nrtma*0.69 + Nbmrt*0.55 = 53 vessels
- For other fisheries, vessels are homogeneous
- Ng = number of ice trawlers, Nc= Number of freezer trawlers

A total target level of exploitation (TAC) is first defined for the reference species (octopus) on the basis of biological research. This TAC has been established at the time of reference (1994) at 40 000 tonnes. The catch of the national fleet (including small scale fishing units) targeting cephalopods and the incidental catches of fleets operating in other fisheries are deduced from the TAC. This leaves an available target catch of about 32 500 tonnes.

This target catch is then expressed in terms of input capacity using actual catch rates and standards fishing effort. For the industrial bottom fishery, the common unit adopted is the number of fishing days for a freezer trawler of 295 GT, of approximately 850 engine power and with a length of approximately 37 m. All Mauritanian and Chinese freezer trawlers are part of this category. Chinese ice trawlers targeting cephalopods have been standardized in relation to the fishing effort of a standard unit. The conversion factor of these Chinese-type ice trawlers in freezer trawlers is 0.67. The Mauritanian ice trawlers target demersals.

For the time of reference, the fleet required to catch the quota, assuming the same fleet profile and full use (289 days per year), is estimated to 79 standard vessels (and corresponding level of standard fishing days).

This target number of vessels is compared to the actual standard fleet targeting cephalopods (as their main target). For the year of reference, the actual standard fleet involved 96 vessels (and corresponding level of actual standard fishing days).

The difference between the authorized and the allowable effort shows either overcapacity or undercapacity. In the above example, fishing capacity on cephalopods, shows an overcapacity of 17 units, i.e. 19 percent.

Similar calculation made for 1998 suggest that a 25 percent cut in fishing effort (or capacity) is required on octopuses, as a reference species. A synthesis of the diagnostics and recommendations proposed for the management of fishing capacity of all the fisheries exploited in Mauritania is given in Annex 1.

### 4.3 Necessary Data

- potential of the resources as issued by research institution;
- catches from commercial fleet;
- specific composition of catches by fishery;
- effort per type of gear within each fishery;
- number of days at sea;
- number of vessels and their characteristics.

## 5. CONCLUSION

The growing over exploitation of fisheries resources is a consequence of the behaviour of fishing fleets (‘race for fish’, etc.) and of a lack of appropriate management measures. This situation generally leads to the development of overcapacity and to overfishing.

Developing States, like Mauritania, are progressively addressing the problem of overcapacity but cannot necessarily address all related issues on their own. *Inter alia*, these countries face serious constraints in elaborating and implementing strategies for controlling fishing capacity and regulating fishing effort, including the difficulty of enforcing legislation and measures aimed at the protection of fisheries resources within their exclusive economic zones.

Overcapacity is often the result of as a result of an excessive build-up of national fishing fleet. In this case, developing States may not have the all the means, financial or otherwise, that are required to address this issue. It may also be the result of an excessive build-up of both national and international fishing fleets. Indeed, foreign fleets authorized to operate within the framework of arrangements or agreements are often seen as a factor contributing to overcapacity. But these agreements are for some countries quite an indispensable source of funds for the national budget and are often negotiated in the broader context of bilateral cooperation.

Mauritania as well as the other countries of the West African Region with high or excessive levels of fishing capacity need technical and financial aid to achieve an appropriate regulation of fishing capacity, protect key stocks from overfishing and develop viable fisheries for resources that remain largely underexploited or unexploited, such as small pelagics and clams.

The management of fishing capacity should be envisaged within a global strategy which takes the following aspects into account: the sustainable exploitation of major resources, guaranteeing economic performances; the protection and enhancement of the resource base; and due consideration of the various components of fisheries resources, such as transboundary stocks, underutilized stocks and discarded species.

It is within this framework that Mauritania has taken, *inter alia*, the following measures:

- freezing capacity/effort on bottom-trawl fisheries;
- prohibiting the substitution of fishing effort on demersals;
- supporting further development in the coastal artisanal fisheries and pelagic fisheries; and
- imposing a two-month biological rest annually for the cephalopod fishery.

These measures have been elaborated within the framework of a national management fisheries plan which aim is to define the allowable potential output (by stocks or areas and the standard effort to authorize with a view to ensuring an efficient and rational use of the EEZ resources.

## Annex 1. Findings of the 1998 working group

| Resources | Current Catches | Natural Variability | Diagnostics | Catch Potential (1) in tonnes | Excess Fishing (2) | Recommendations | Data Quality | Assessment Quality | Observations |
|---|---|---|---|---|---|---|---|---|---|
| **Cephalopods** | | | | | | | | | |
| Octopus | 20 000 | ? | Over-utilized | ~ 35 000 (21 000 to 40 000 t) | $\Rightarrow$ 25% | Need to reduce fishing effort and not to increase fishing pressure on juvenile stocks | Good | Rather satisfying, Reliable diagnostics on over utilization but Unreliable Potential estimate | Need to undertake studies on age structure and relation to environment |
| Cuttlefish | ~ 5 000 | | Probably fully to over exploited | ~ 10 000** | Not known | Need to apply the precautionary approach and encourage the use of selective gears | | Very weak | Need to undertake biological studies |
| Squid | ~ 2 000 | Average | Not known | ~ 6 000** | Not known | | | Very weak | |
| **Demersals** | | | | | | | | | |
| Off shore species | Not known | Average | Probably under to fully exploited | 10 to 15 000** | Probably low or none | Prevent any fishing effort increase | Complete data | Very weak | Only off shore data can be used |
| Coastal species | Not known | Average | Probably under to fully exploited | Not known | Probably | Freeze effort | Very incomplete data | Very weak | Id |
| Hakes | 11 000 | Average | Probably under exploited, increase in biomass | > 13 000 (national area) | None | Control effort until a more precise assessment is undertaken | Incomplete | Bad and does not concern national area | Lack of biological information and data |
| Mullets | 2-4000 t | | rapid increase in fishing effort | Not known | Not known | Freeze effort | Very weak | No assessment can be undertaken | Under review at the CNROP |

*Findings of the 1998 working group (continued)*

| Resources | Current Catches | Natural Variability | Diagnostics | Catch Potential (1) in tonnes | Excess Fishing (2) | Recommendations | Data Quality | Assessment Quality | Observations |
|---|---|---|---|---|---|---|---|---|---|
| **Crustaceans** | | | | | | | | | |
| Deep sea shrimp | 1 600 | High | Probably fully exploited | 2 500 | Weak | Freeze effort | Bad | Very weak, empirical method | Shrimp potential estimated on the basis of shrimp catch over the last ten years |
| Coastal shrimp | 1 000 | High | Probably fully exploited | 1 500 | Weak | Freeze effort | Bad | Very weak, empirical method | |
| Crabs | 300 | High | Probably fully exploited | 400* | None | Freeze effort | Bad | Weak | |
| Pink lobster* | 200 | High | | 800* | Not known | | | Insufficient | |
| Green Lobster* (2 stocks) | 100 | High | Northern stock probably in the process of replenishment | 220* | Weak | Wait before any effort increase | Very Bad | incomplete 1988 assessment, no 1998 assessment | Need to estimate Southern stocks |
| **Clams** | | | | | | | | | |
| *V. rasalina* | 0 | High | Not utilised | < 300 000 | None | | Weak | 1993 assessment | |
| *V. verrucasa* | 0 | High | Not utilised any more | 500 – 1000* | Id. | | Weak | 1993 assessment | |

*Findings of the 1998 working group (continued)*

| Resources | Current Catches | Natural Variability | Diagnostics | Catch Potential (1) in tonnes | Excess Fishing (2) | Recommendations | Data Quality | Assessment Quality | Observations |
|---|---|---|---|---|---|---|---|---|---|
| **Pelagics** | | | | | | | | | |
| Sardinellas | 400 000 | Extremely high | Decreasing biomass (acoustic data) | 750 000* | | | Improve biological data and Catch data | Weak | Inshore component not evaluated |
| Horse Mackerel | 160 000 | Extremely high | Decreasing biomass (acoustic data) | 400 to 600 000 t | | A maintained effort or a 20% effort increase would be sustainable | Id | Weak | Inshore component not evaluated |
| Mackerel | 53 000 | | | | | | Insufficient | | |
| Hairtail | 81 000 | | | | | | Insufficient | | |
| Tuna | | | | | | | | | |
| • Yellow fin | 1 500 | Low | Fully Exploited | Atlantic stocks | None – Low | Freeze effort and fix minimal size | Good | Satisfying | ICCAT assessment, Atlantic Management |
| • Skipjack | 20 000 (1997) | Low | Id | id | None | None | Good | Satisfying | |
| • Bigeye | 2 500 | Low | Id | id | None - Low | Freeze effort | Good | Satisfying | |

1. Maximum Sustainable Yield (MSY) (Note: this potential can only be reached by fixing a corresponding effort level (FMSY), which in some cases imply a decline in effort; 2. Current excess in fishing effort to reach catch potential ((f98-fMSY) / f98) ; 3. Natural variability of stocks independently from the exploitation (recruitment variability);
* No assessment was undertaken in 1998. 1993 Values and recommendations. ** No 1998 assessment. 1998 Values and recommendations.