

# Recent Development of Swordfish, *Xiphias gladius*, Longline Fisheries near Reunion Island, Southwestern Indian Ocean

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## ABSTRACT

A substantial increase in French longlining activity targeted on swordfish has been observed between 5°S and 35°S in the western Indian Ocean since 1992. The domestic fleet increased from one unit in 1991 to 15 in 1994. Other countries active in the area are Taiwan, with an estimated 150 longliners, and Spain, with five 45-m longliners. Initially concentrated near the island of Reunion, French activity presently extends to the entire French Exclusive Economic Zone surrounding Reunion and southward to 26°S.

The catch of the Reunion fleet increased from 41 metric tons (t) in 1992 to approximately 700 t in 1994. In 1994, swordfish represented 65% of the catch (in number); mean catch was 14 fish per 1,000 hooks, and mean weight of fish was 50 kg. Sales on the local market are low. The high-quality product is transhipped fresh by air to Europe, and the lower grade is frozen.

The development of this fishery stresses the need to develop a program in cooperation with other countries in the southwestern Indian Ocean to improve knowledge of the biology of swordfish, its relation to the environment, and fishing activity, in order to assess and manage the stocks in the long term.

## Introduction

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The domestic swordfish, *Xiphias gladius*, fishery was virtually nonexistent a few years ago around the island of La Reunion, an overseas department of France in the southwestern Indian Ocean. Beginning in 1991, two factors promoted the rapid development of this fishery. First, the favorable conditions for swordfish in the southwestern Indian Ocean and the success of the Asian fleet based on the island inspired a local fisherman to begin longline trials with a 12-m boat. Second, new tax regulations offering exemption for certain investments in French overseas departments encouraged fishing companies from the mainland to come to Reunion. Four 16-m longliners based at Pointe des Galets harbor started

operating in 1992, targeting bigeye tuna destined for the Japanese market. Information on the success of this fishery spread rapidly. There have since been significant changes in various aspects of the swordfish fishery, including the evolution of boat and gear characteristics, fishing techniques, fishing grounds and seasonal activity, target species, and markets.

In 1993, the Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) began a program in Reunion to study and monitor the swordfish fishery, analyse the catch, and improve knowledge on the biology of swordfish and billfish from the southwestern Indian Ocean. The Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM) contributes to this program, specifically by producing weekly surface

temperature charts from satellite images. These charts, which are produced for the Regional Tuna Project, Phase 2, of the Commission de l'Océan Indien (COI), are distributed to participating countries: Comoros, France, Madagascar, Mauritius, and Seychelles.

This paper describes the swordfish fisheries in the southwestern Indian Ocean and the data which have been collected on them, and presents an analysis and evaluation of geographical swordfish distribution, catches, and catch per unit effort. Along with brief histories of the fisheries, we describe the fishing strategies of the various fleets operating in the zone, to examine their fundamental differences and to draw out the positive developments of the emerging fishery based at Reunion Island.

## The Fisheries

### Vessels

**Domestic Fleet**—The characteristics of the vessels composing the Reunion fleet are summarized in Table 1. Four companies are represented, operating a total of 15 vessels.

**Taiwanese Fleet**—The Taiwanese longline fishery is very active in the Indian Ocean, with probably 150 longliners operating in the French Exclusive Economic Zone (EEZ) around Reunion Island. In 1994, 28 vessels received licenses to fish in the EEZ, on condition that the catch is landed in Reunion. These vessels are 35–45 m long, between 145 and 380 horsepower, and have a capacity of at least 100 metric tons (t), with 18–30 men on board. A large proportion are equipped with freezing holds ( $-60^{\circ}\text{C}$ ).

**Spanish Fleet**—There is little or no information available on the Spanish fleet. Five 45-m longliners operate

occasionally in international waters in the southwestern Indian Ocean. These vessels were redeployed from the Spanish fleet of longliners in the northeast Atlantic. They arrived on an exploratory cruise at the end of 1993 and in early 1994.

### Fishing Gears and Methods

All the Reunion vessels use a system of drifting longline which utilizes a main spool and a line shooter. The main line is a nylon monofilament 3.5 or 4 mm in diameter and approximately 45–80 km long. The line can be weighted to control its depth in strong currents. The leaders with hooks (size 8/0 or 9/0) are 10 m long and 2 mm diameter, and are attached to the main line with snaps. Depth is controlled by a series of intermediate floats attached to the main line with leaders of 5–25 m. In addition a larger float is used to separate the various sections of 60–100 hooks. Between 500 and 1,400 hooks are utilized for each set. The buoys at the end of the longline are equipped with a strobe light and a radio system to assist in retrieval. There may be various modifications to the fishing gear, these being determined by the requirements of individual skippers.

Because swordfish is the target species, the longline is always set in the evening. Kume and Joseph (1969) have shown that lines set at night are more productive for capturing swordfish than lines set during the day. A line shooter draws the line from the main spool and controls its setting speed. Clipping of the leaders on the main line and baiting of the hooks takes place progressively during each set. Squid is generally used as bait in addition to a light stick (Cyalume<sup>1</sup>) placed 1 m above the hook. This whole operation requires three crew-

<sup>1</sup> Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

**Table 1**  
Specifications of the longliners of the Reunion fleet.

|                                   | Company                  |         |         |                    |        |     |
|-----------------------------------|--------------------------|---------|---------|--------------------|--------|-----|
|                                   | Compagnie des Longliners |         | Sopesud | Pointe de la Table | Creole |     |
| Number of units                   | 3                        | 1       | 8       | 1                  | 1      | 1   |
| Length (m)                        | 25                       | 20      | 16      | 12                 | 12     | 12  |
| Bunker capacity (m <sup>3</sup> ) | 48                       | 23      | 13      |                    | 2.5    | 2   |
| Crew                              | 9                        | 7       | 6       | 5                  | 4      | 4   |
| Horsepower                        | 600                      | 2 × 350 | 350     | 200                | 250    | 213 |
| Insulated hold (m <sup>3</sup> )  | 120                      | 50      | 28      | 20                 | 12     | 9   |
| Ice machine                       | yes                      | yes     | yes     | no                 | no     | no  |
| Regulated hold (0°C/-20°C)        | yes                      | yes     | yes     | no                 | no     | no  |
| Regulated hold (-40°C)            | yes                      | yes     | yes     | no                 | no     | no  |

men on deck and one at the helm. The longline is set in 4–6 hr cruising downwind.

The line is hauled after sunrise. The duration of the haul depends on the catch and sea conditions. The number of days at sea varies according to vessel size and capacity, and weather conditions. Small vessels stay at sea from 2 to 8 days, while vessels longer than 16 m stay at sea 7–18 days.

Very little information is available on the fishing techniques of the Taiwanese fleet. It is known, however, that the Taiwanese do not use a monofilament longline and therefore require a large crew. At least 2,000–2,500 hooks are utilized for each set. The target species are albacore and bluefin, bigeye, and yellowfin tuna. Mackerel is generally utilized as bait.

No information is available concerning techniques utilized by the Spanish fleet. These are most likely as described by Rey and Alot (1984).

### Onboard Catch Processing

Handling and treatment of the catch depends on the type of vessel and market requirements. Two processing techniques are utilized: swordfish are headed and gutted (H&G): head, guts, gills and fins are discarded; or the fish are gutted only: guts are discarded and the head is left on, with the gill discarded. The latter treatment is generally carried out on pieces of less than 20 kg. In Reunion, fish destined for export are carefully and individually processed on board on ice in order to conserve quality.

On Taiwanese albacore longliners, the entire catch is placed in  $-45^{\circ}$  or  $-60^{\circ}\text{C}$  holds after processing (H&G). Billfishes are not subject to any particular special treatment. On Taiwanese longliners targeting bluefin, bigeye, and yellowfin tuna (“sashimi boats”), the entire catch is placed in  $-60^{\circ}\text{C}$  holds. Fish are carefully treated taking into account the special requirements of sashimi buyers.

### Marketing

**Reunion Longliners**—In an effort to control the regional market, only local companies are presently allowed to sell on the Reunion market. The portion of the catch destined for export is processed by a specialized company. Swordfish and tuna loins of 3 kg are vacuum-packed in temperature-controlled packaging and air-freighted to Europe.

The Compagnie des Longliners exports its entire catch, for which purpose it has established a joint venture with an American company which specializes in the marketing of fresh swordfish and high-quality tuna.

Quality control is carried out before export. The fresh products are primarily exported to Europe (90%) and the United States (10%). Fresh fish that are not of export quality are frozen and exported at a later date to other markets.

As the result of a flooded market following the first year of production, there was a sharp drop in the price in Spain, France, Italy, and Germany. The world demand for fresh swordfish allowed profitable returns of around US\$4 per kilo.

The various strategies for exporting fresh fish by air from Reunion, including techniques of preservation and controlled packaging, have been determining factors in the evolution of the industry and have added value to this limited resource.

**Taiwanese and Spanish Vessels**—The Star Kist company purchases the catch of the Taiwanese albacore longliners, which is exported in bulk-freezer vessels to canneries in Puerto Rico. The sashimi boats transship their catch in Japanese shuttle vessels equipped with bulk deep-freezers; it is purchased by traders in Japan. The marketing of the catch from the Spanish fleet is undocumented.

### Data Collection

#### Domestic Fleet

Logbooks were distributed to all Reunion longliners to collect information on fishing positions, number of hooks per set, light sticks used, fishing gear techniques, times that line is set and hauled, number of fish caught by species, and their estimated weights. Environmental and weather conditions (sea-surface temperature, wind speed and direction, etc.) are also recorded. The logbooks are collected regularly from the skippers or company managers.

Fishing statistics for Reunion's fleet are determined on the basis of voluntary declarations of catches by skippers and companies to the Fisheries Administration. Available data on catches represent the comprehensive results of fishing operations by all registered companies. The companies must declare the date of the departure and arrival of each of their vessels as well as the total catch by species (13 species). In order to confirm the information received, port sampling and on-board observer programs are also conducted.

#### Other Fleets

Authorization to fish in the French EEZ for a period of one year was granted to 28 Taiwanese longliners in

November 1993. This agreement requires that Star Kist hand over logbooks completed by captains and indicating precise fishing positions, number of hooks per set, and total catch transhipped at the port of Pointe des Galets.

Fishing statistics on the Asian fleet are organized and published by the Indo-Pacific Tuna Development and Management Programme (IPTP) of the FAO, based on

declarations from individual countries. No data are available on the Spanish fishery.

## Results and Discussion

Because the logbooks only cover a portion of fishing activities, a coverage rate has been established, defined as the ratio between the number of trips listed in the logbooks and the estimated number of total trips by the entire Reunion fleet. The coverage rate was 24% in 1992, 40% in 1993, and 95% in 1994.

### Fishing Grounds

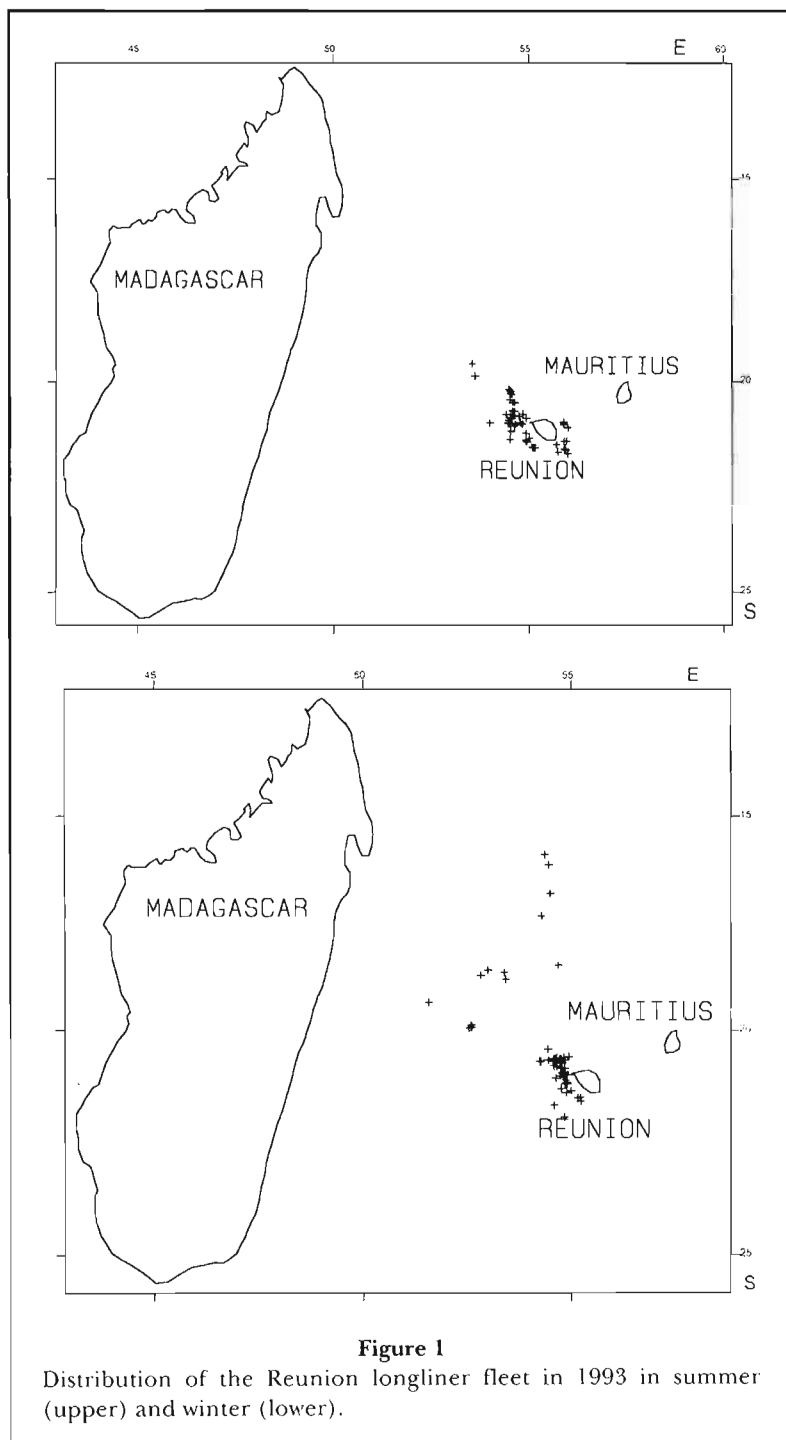
Figures 1 and 2 show the distribution of the Reunion longliner fleet in 1993 and 1994. Each cross represents the starting position of a set during one fishing day. Figure 3 shows the fishing operations of the 21 Taiwanese longliners in winter 1993 and summer 1994.

### Species Caught

An exhaustive list of species caught was begun by compilation of fishing logbooks and was completed by scientific observers during trips onboard longliners based in Reunion (Table 2). The processing carried out on the catch by the Taiwanese longliners makes species identification difficult; however, *Lampris guttatus* was detected in the catch.

### Quantities Caught

Figure 4 shows swordfish catches by the major countries fishing for swordfish in zone 51 of the FAO (30°–80°E) during 1984–93 (IPTP<sup>2</sup>). The increasing catches of swordfish and albacore by the Reunion fleet during 1991–94 are depicted in Figure 5. Increasing targeting on swordfish by the Reunion longliners during 1992–94 is reflected in Figure 6, which shows the proportions of major species caught during that time. The



<sup>2</sup> Indo-Pacific Tuna Development and Management Programme (IPTP). 1994. Indian Ocean and Southeast Asian tuna fisheries data summary for 1994.

monthly variation by species of catch by Taiwanese longliners is presented by number of fish in Figure 7, and by percentages in Figure 8.

### Effort

Not only the number, but the size of French longliners based in Reunion have increased since 1991 (Fig. 9). Between 1991 and 1994, both the number of boat days at sea and the amount of effort, estimated as the number of hooks set, increased more than 20-fold (Table 3). The seasonal distribution of effort by the Taiwanese fleet from July 1993 to February 1994 is presented in Table 4.

### Catch Per Unit of Effort

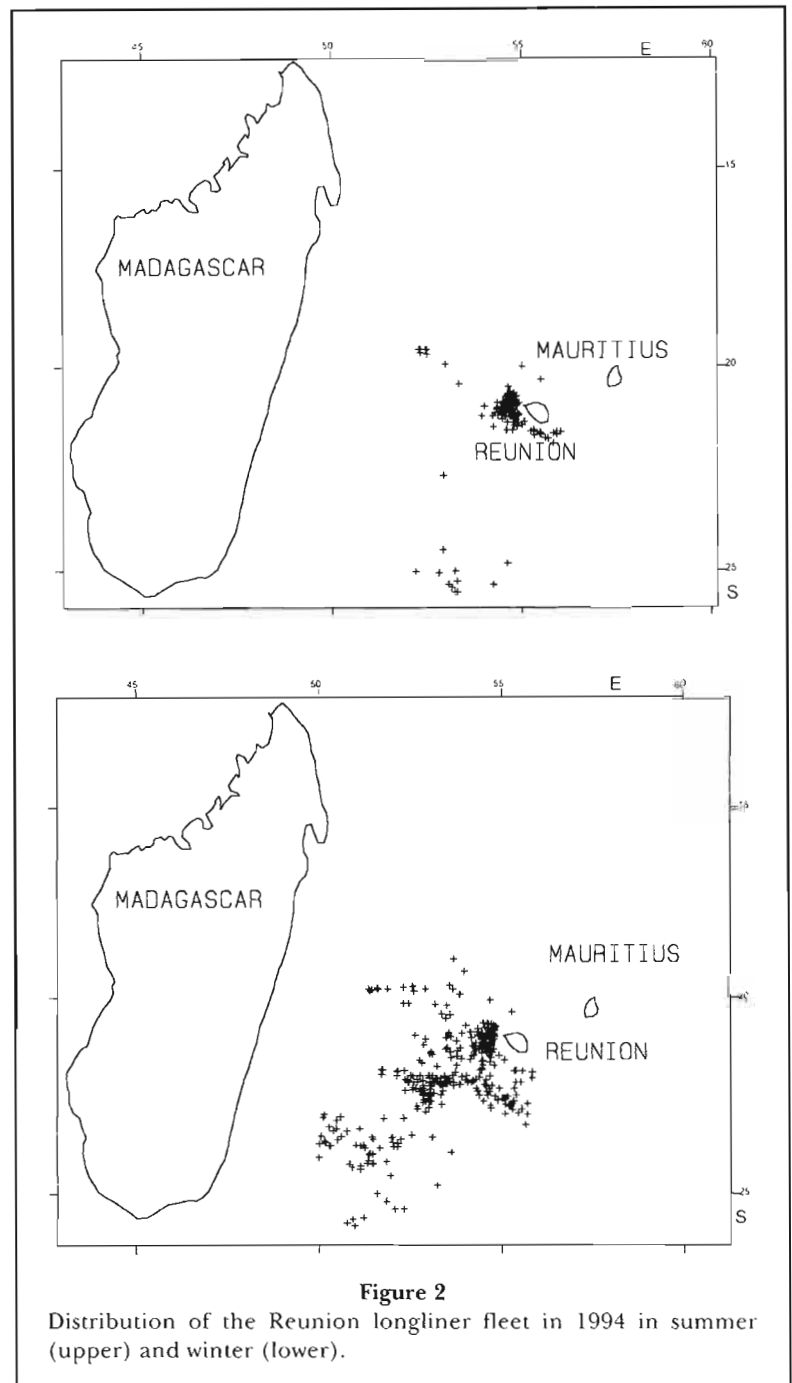
The 1993–94 spatial distribution of swordfish catch per unit effort (CPUE) of the Reunion longliner fleet is illustrated in Figure 10, and that of the 21 Taiwanese longliners in Figure 11. CPUE by species for the Reunion longliners (in weight per boat-day at sea) from March 1992–September 1994 is shown in Figure 12. Monthly CPUE (fish caught per 1,000 hooks) for swordfish, albacore, and other species) caught by the Reunion and Taiwanese longliner fleets is presented in Figure 13.

## Discussion

### Reliability of the Data

Most companies and skippers have cooperated well with the new system of collecting catch logbooks, introduced in November 1993. In exchange for the data, complete confidentiality is guaranteed. Raw (unaggregated) data are not disclosed or published. These logbooks provide very solid information on the position of sets, techniques used, environmental conditions, and number of fish caught by species.

Analysis of the data has shown some limitations to this system. When total daily catch is compared with the actual transshipment figures, differences of up to 20% appear; therefore, the catch estimates provided by the skippers must be viewed cautiously. There was also discrepancy between data on fishing periods collected by the Fisheries Administration and by ourselves, for ex-

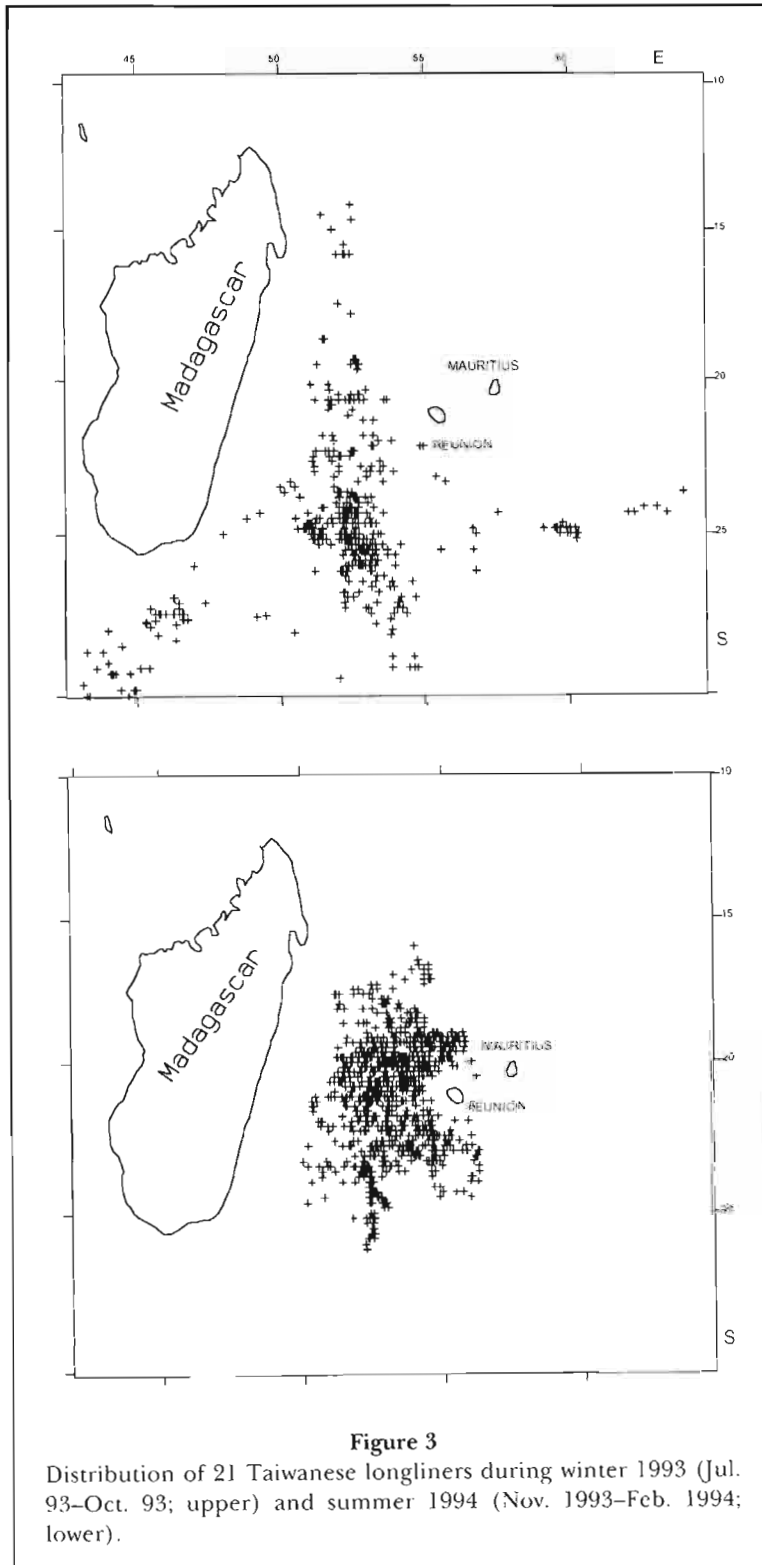


ample, the dates of the start and end of fishing trips were different.

It would be useful in the future 1) to include a recapitulation table in the declaration forms, in which the number and weight of fish unloaded would be summarized by species; 2) to furnish a size-weight conversion table to each skipper in order to improve estimates; and 3) to add to the declaration forms further required information, such as number of sets per trip and number of each species caught.

Concerning the catch declarations of Taiwanese longliners, two types of information are provided, the number of fish caught and the total tonnage of each species unloaded. There are many inconsistencies, prob-

ably as a result of transshipment at sea and at other ports. In order to improve the quality of the data it would be necessary to place observers aboard and to monitor this fishery on a regional level, over the entire Indian Ocean.



### Fishing Grounds and Seasons

**Domestic Fleet**—The fishing grounds of the Reunion longliners are to the west and south of Reunion in the French EEZ and in international waters. No longliners are authorized to fish within a zone of 30 nautical miles (n. mi.) from Reunion, in order to avoid conflicts with the artisanal tuna fishery.

The period of the most intensive fishing activity corresponds to austral summer. It appears that the seasonal abundance around Reunion could be related to the migration of mature fish, which congregate in this zone during summer.

The youngest females observed, stage 6 on the scale of maturity (Uchiyama and Shomura, 1974), were observed in the month of November; females in the phase of atresia have been observed in April near Reunion Island. During the month of January, swordfish larvae have been observed in the Mozambique Channel (Kondrinskaya, 1970) as well as off the east coast of Madagascar (Gorbunova, 1969).

The violent trade winds that characterize the southern winter limit boats of the domestic fleet, which are not designed for distant water operations. In addition, the smaller vessels are incapable of manufacturing ice. Thus during the winter 12-m vessels prefer to pursue demersal fishes on banks off the Mauritian islands of Rodrigues and Soudan.

The activity of the domestic fleet has significantly evolved in the last 3 years. This is illustrated by Figures 1 and 2, which show the progressive spatial extension of fishing. The catch zone west of Reunion in 1993 expanded to the southwest in 1994, with maximum catches between 30 and 60 n. mi. to the west and southwest, extending southwestward beyond the 200-n. mi. zone. Figure 12 illustrates changes in the monthly average catch per unit effort, which displayed strong seasonal trends. In 1994 there was no winter decrease in catch rate, a consequence of progressive mastery of fishing techniques by the crews. This promoted a positive balance of accounts for companies in 1994 and ensured a constant

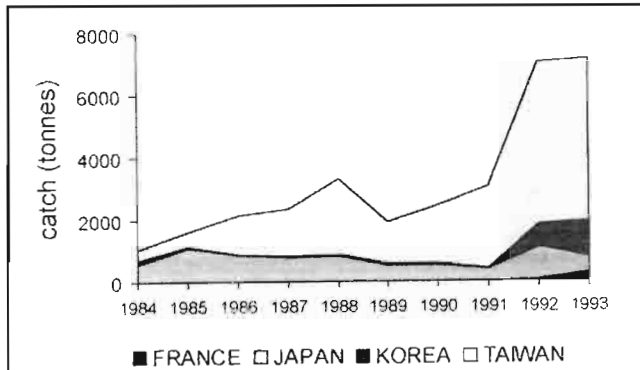


Figure 4

Swordfish catch by longliners of the main countries fishing swordfish in FAO zone 51, 1984–93 (from IPTP<sup>1</sup>).

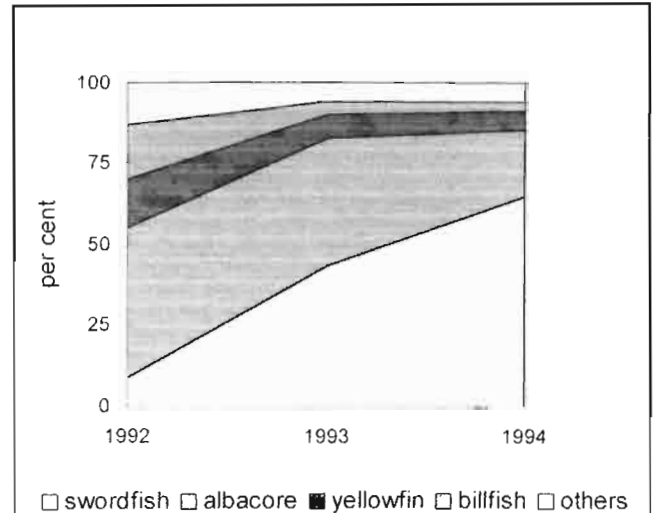


Figure 6

Proportions (by number of fish) of main species caught by Reunion longliners, 1992–94.

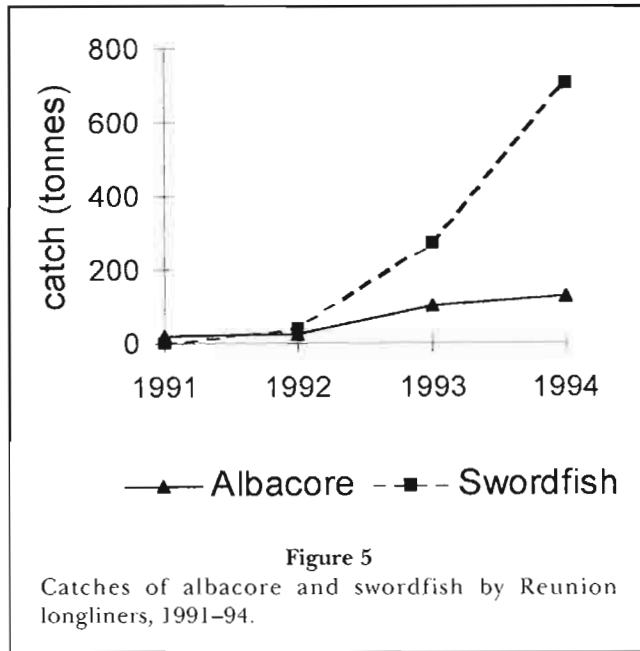


Figure 5

Catches of albacore and swordfish by Reunion longliners, 1991–94.

supply of exports to penetrate international markets. The arrival of more powerful vessels, improvement and mastery of fishery techniques, and the discovery of new zones of exploitation could all bring further notable changes to current strategies.

**Taiwanese Longliners**—The seasonality and fishing grounds of the Asian fleet are not precisely known. These vessels are constantly on the move, searching for bigeye, albacore, and bluefin tuna. It seems that this fleet operates during the austral summer between 10°N and 25°S, and between 25°S and 35°S during the winter, when they target juvenile albacore. No precise data

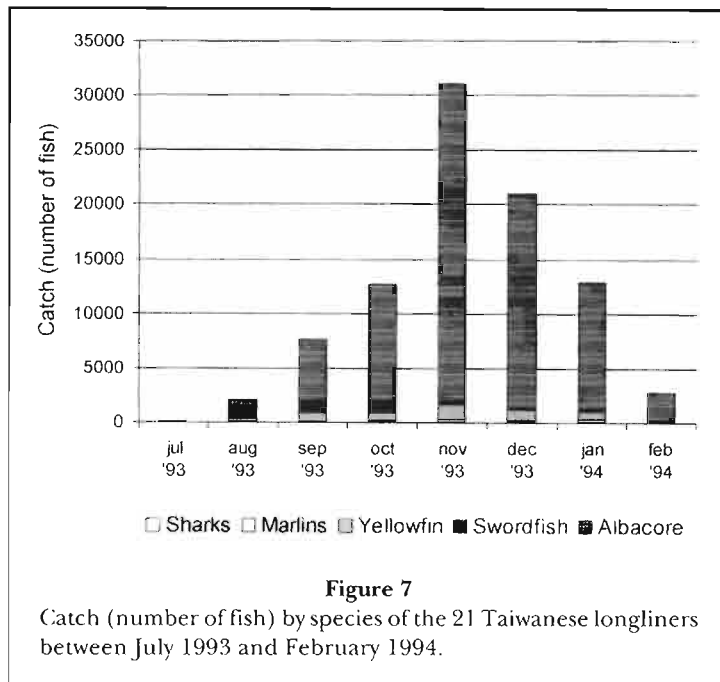
is available on their activity in the EEZ between 35°S and 40°S. The movements of this fleet are known only from a sample of 21 boats out of a total fleet of 150 in the EEZ around Reunion Island and Mauritius between July 1993 and February 1994. It would appear, according to information obtained by scientists from Seychelles, Mauritius, Madagascar, and the Comoros, that at least 300 vessels were listed during 1994 in the region southwest of Reunion.<sup>3</sup>

**Spanish Longliners**—Contacts have been established with the Spanish Oceanographic Institute (IEO) and the European Economic Community (EEC), which financed the redeployment of vessels from the Atlantic to the Indian Ocean, to obtain more information on this venture. These 5 vessels seem to obtain excellent results to the south of Madagascar and in the Mozambique Channel, but no data are available to date.

**Catch**

**Reunion Fleet**—A considerable and progressive increase in swordfish landings by the domestic longline fleet was recorded during 1992, 1993, and 1994, from approximately 1 t in 1992 to 600 t in 1994 (Fig. 5). The number

<sup>3</sup> Statistical meeting of the Regional Tuna Project, phase 2 (PTR2) of the Indian Ocean Commission. Albion, Mauritius, July 1994.



**Figure 7**

Catch (number of fish) by species of the 21 Taiwanese longliners between July 1993 and February 1994.

**Table 2**

Fish species caught by the longliners of the Reunion fleet.

| Target species   | Bycatch species                                    |
|--|--|
| Swordfish, <i>Xiphias gladius</i>                      | Skate, unidentified                                |
| Albacore, <i>Thunnus alalunga</i>                      | Ocean sunfish, <i>Mola mola</i>                    |
| Yellowfin tuna, <i>Thunnus albacares</i>               | Snoek, <i>Thyrsitoides</i> sp.                     |
| Bigeye tuna, <i>Thunnus obesus</i>                     | Oilfish, <i>Ruvettus</i> sp.                       |
| Dolphin fish, <i>Coryphaena hippurus</i>               | Remora, <i>Remora</i> sp.                          |
| Sailfish, <i>Istiophorus platypterus</i>               | Crocodile shark, <i>Pseudocarcharias kamoharui</i> |
| Blue marlin, <i>Makaira nigricans</i>                  | Silky shark, <i>Carcharinus falciformis</i>        |
| Shortbill spearfish, <i>Tetrapturus angustirostris</i> |  |
| Shortfin mako, <i>Isurus oxyrinchus</i>                |  |
| Oceanic whiteup shark, <i>Carcharinus longimanus</i>   |  |
| Scalloped hammerhead, <i>Sphyrna lewini</i>            |  |
| Smooth hammerhead, <i>Sphyrna zygaena</i>              |  |
| Blue shark, <i>Prionace glauca</i>                     |  |

of swordfish caught from March 1993 to December 1994 can reasonably be estimated at 8,000, corresponding to 410 t dressed weight. This increase in the catch has made this fleet one of the major players in the Indian Ocean (Fig. 4).

**Taiwanese Fleet**—Changes in the Taiwanese catch by species and by month has been calculated from log-book data on fish caught by 21 vessels. In 8 mo, 4,152 swordfish were caught. Representation in weight is not useful because landing tonnage does not match the catch, due to long trips and transfers at sea.

**Spanish Fleet**—The Spanish catch cannot be quantified at present.

### Effort

**Reunion Fleet**—During 1991–94 there was a regular and rapid increase of fishing effort (Table 3). This seems mainly due to an increase in the national fleet, which has grown from 1 to 15 vessels in 3 yr (Fig. 9); increased numbers of trips and sets, with a transition from a seasonal to a year-round operation; an increase in the

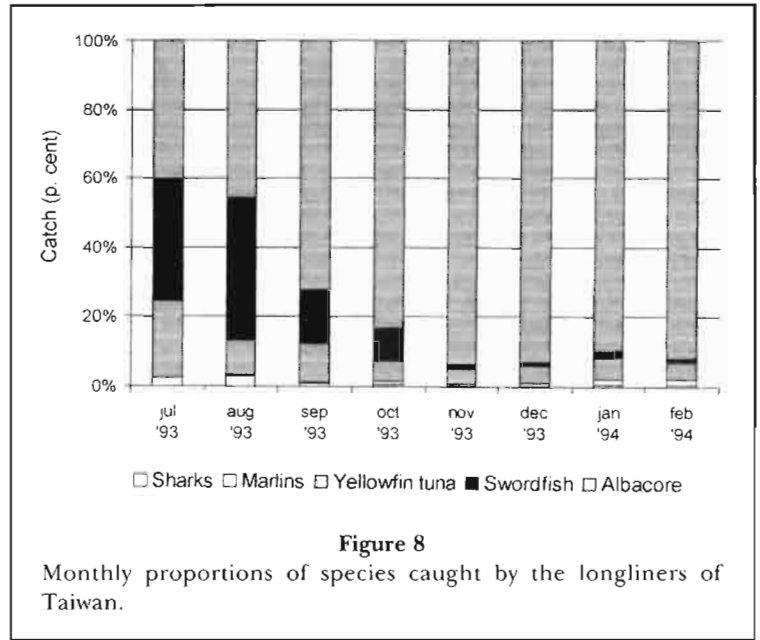


number of hooks per set; and a major expansion of the fishing grounds.

**Taiwanese Fleet**—The effort of the Taiwanese fleet is known only from the declaration made by 21 vessels from July 1993 to February 1994, indicating a probable presence of approximately 150 vessels. These figures would have to be multiplied by 7 or 8 to give a more realistic indication of the Taiwanese fishing effort.

**Catch Per Unit of Effort**

In 1993, the best CPUE for the domestic fleet was within 70 n. mi. of Reunion (Fig. 10). The catch in this area ranged between 10 and 15 fish per 1,000 hooks. In 1994, there was an important increase in CPUE over the whole fishing grounds, with a zone of optimum catch distributed around a northeast–southwest axis 50–300 n. mi. from the island. In this zone there were 25–35 captures/1,000 hooks. For the Taiwanese fleet in 1993–94, the best CPUE on the entire fishing grounds was 20 fish/1,000 hooks. This was in a zone situated on a northeast–southwest axis in the Madagascar EEZ, 100 n. mi. to the southwest of the most productive area identified by the domestic fleet. Another productive zone (5–20 fish/1,000 hooks) appears in the Mozambique channel southwest of Madagascar.



**Figure 8**  
Monthly proportions of species caught by the longliners of Taiwan.

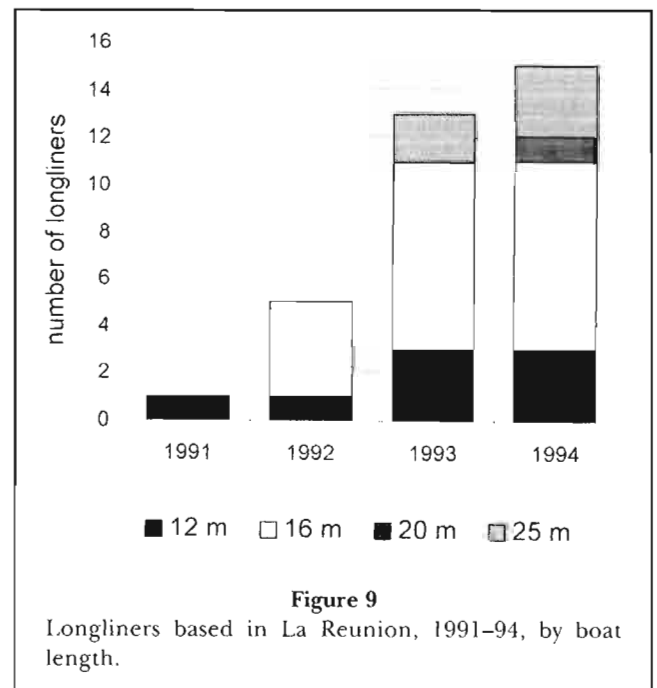
Analysis shows that these zones of high CPUE are all situated in the southern tropical convergence zone next to the Agulhas Current in the Mozambique channel and the Malagasy Southeast Current off Madagascar. Oceanographers have found several vortices and meanders in the surface circulation, which can generate a succession of divergence and convergence zones (Donguy and Piton, 1991; Marsac, 1994). Even if it is not possible to model these and to explain them at the

**Table 3**  
Fishing effort of Reunion longliners, 1991–94.

| Year | Trips | Boat days at sea | Hooks ( $\times 10^3$ ) |
|------|-------|------------------|-------------------------|
| 1991 | 20    | 43               | 28                      |
| 1992 | 59    | 155              | 70                      |
| 1993 | 142   | 841              | 549                     |
| 1994 | 173   | 1,048            | 690                     |

**Table 4**  
Fishing effort of Taiwanese longliners (21 vessels) off Reunion, July 1993–February 1994.

| Year/quarter | Sets  | Hooks ( $\times 10^3$ ) |
|--------------|-------|-------------------------|
| 1993/3       | 155   | 505                     |
| 1993/4       | 841   | 3,586                   |
| 1994/1       | 1,048 | 1,386                   |



**Figure 9**  
Longliners based in La Reunion, 1991–94, by boat length.

present time (Petit, 1991), fishermen are successful in reducing search time and increasing catch rate by using satellite temperature data to locate convergence zones.

The spectacular increase in catch rate of the domestic fleet (Fig. 12) is largely due to the ability of crews to improve on American techniques; accurate targeting of swordfish with techniques including light sticks, setting at night, adaptation of gear according to the lunar cycle, and utilization of XBT profiles and bathymetric data; and more systematic utilization, since July 1993, of satellite thermal charts, allowing boats to locate thermal fronts and to position their gear accordingly. These charts are now considered crucial by the skippers.

Comparison between the domestic and Taiwanese fleets shows that the catch rates of the domestic fleet are clearly superior for all species (Fig. 13).

### Targeting and Bycatch

Figures 5 and 6 reveal a change in targeting by the domestic fishery. Swordfish accounted for only 7% of the catch (in number) in 1992, but 65% in 1994. One will also notice a progressive drop in the catch of billfishes (marlins, sailfish, and spearfish; Fig. 6) which underscores the specificity of the techniques employed. This confirms that it is possible to exploit swordfish without prejudice to recreational game fishing activities based on billfish in nearby countries. As for sharks, by reason of their current weak market value, only dead individuals are preserved and posted as catches. Live ones, which are usually more numerous, are released. Capture of sharks remains marginal.

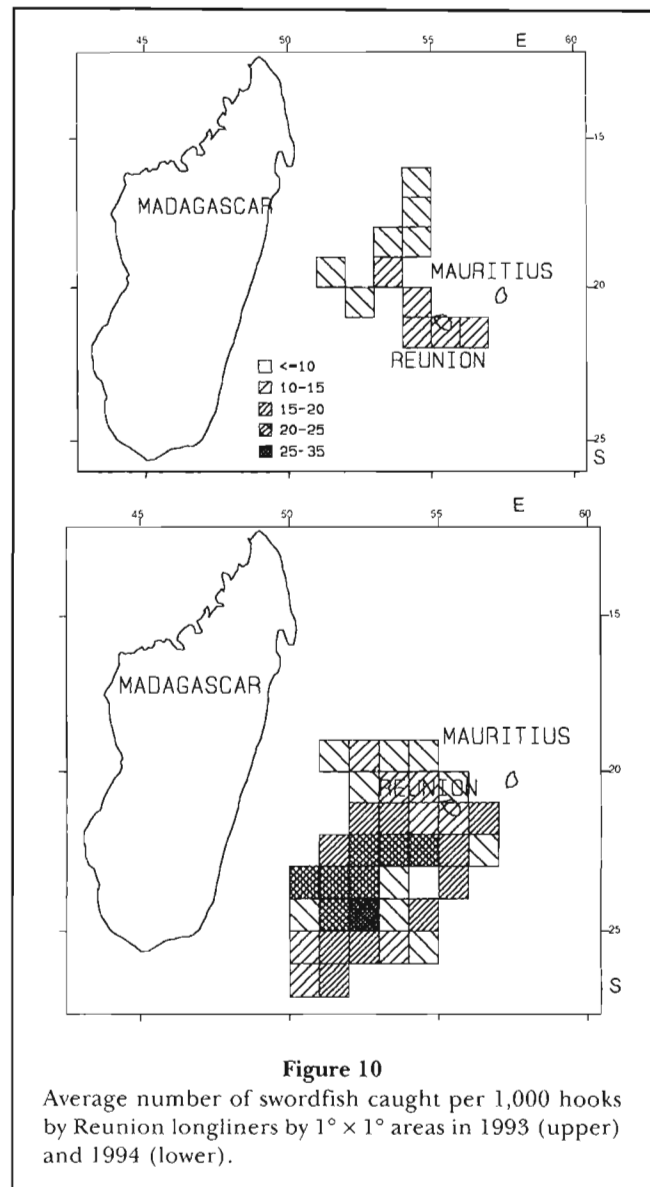
### Predation after Capture

Predation is weak (<1%) and seasonal. Nevertheless, the catch of a set can be totally destroyed by predation, mainly by sharks, short finned pilot whales, *Globicephala macrorhynchus*, and false killer whales, *Pseudorca crassidens*.

### Conclusion

The longline fishery has been operating in the Indian Ocean for about forty years. This activity was traditionally dominated by Asian fleets until the 1980's.

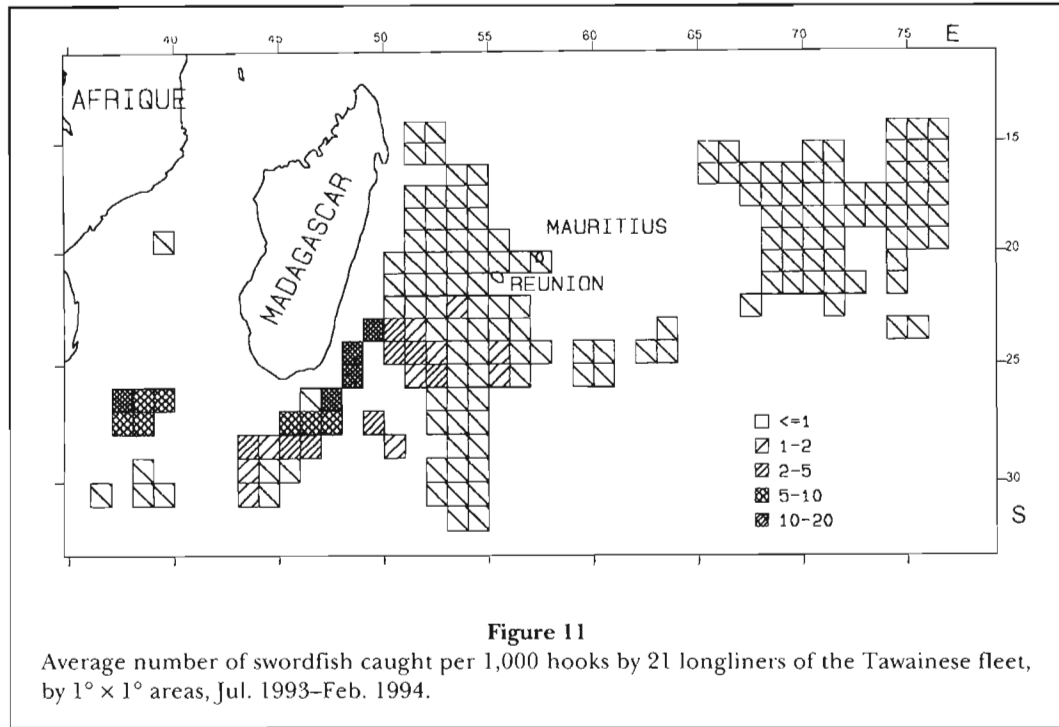
The French tuna fishery in the Indian Ocean began with the arrival of a purse seiner fleet from tropical Atlantic waters. Reunion Island developed a domestic longline fishery, which was more suited to the exploitation of pelagic resources in oligotrophic subtropical waters. In the early stages, tax exemptions and the arrival of fishermen from the mainland created the necessary incentives for the development of these ac-



tivities. Today, these two factors no longer play a crucial role. The growing harvest of pelagic resources by Reunion-based fishermen and companies has involved regional participation and development in three direct ways: upgrading of the artisanal fishery using new, specially-adapted 12-m longliners; involvement of local investors; and education and training of local fishermen in longlining techniques.

Some improvements have yet to be undertaken: all longliners need adequate working space on deck, and cold storage from  $0^{\circ}\text{C}$  to  $-60^{\circ}\text{C}$ ; and local seafood quality control services should be improved, in particular to meet the new standards established by EEC regulations.

In addition, management strategies for swordfish stocks should be developed and improved, based upon

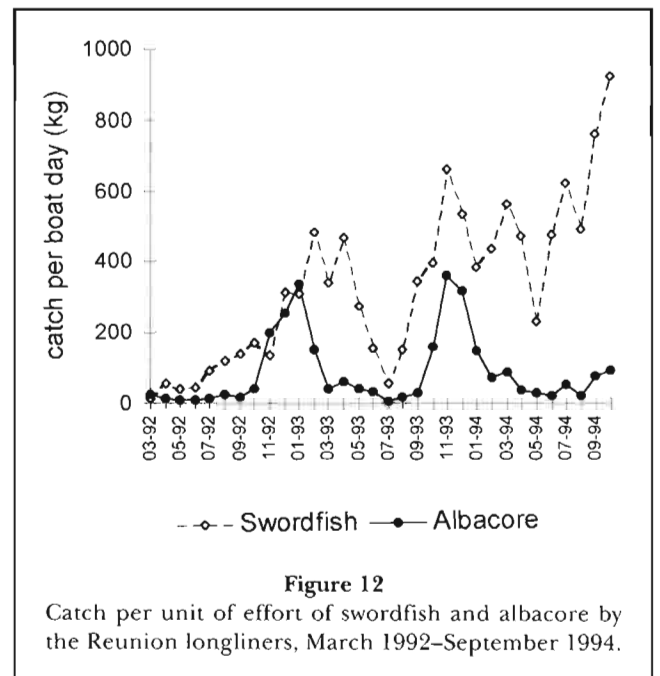


the management problems faced in other geographical areas. A major program could be structured through

- data collection on catches and transshipments at all major southern Indian Ocean ports;
- estimation of an index of abundance based on catch and effort data;
- setting up a biological program to study ageing, reproduction, migration, and behavior;
- data collection on bycatch; and
- study of the potential effects of environmental conditions on the distribution of swordfish.

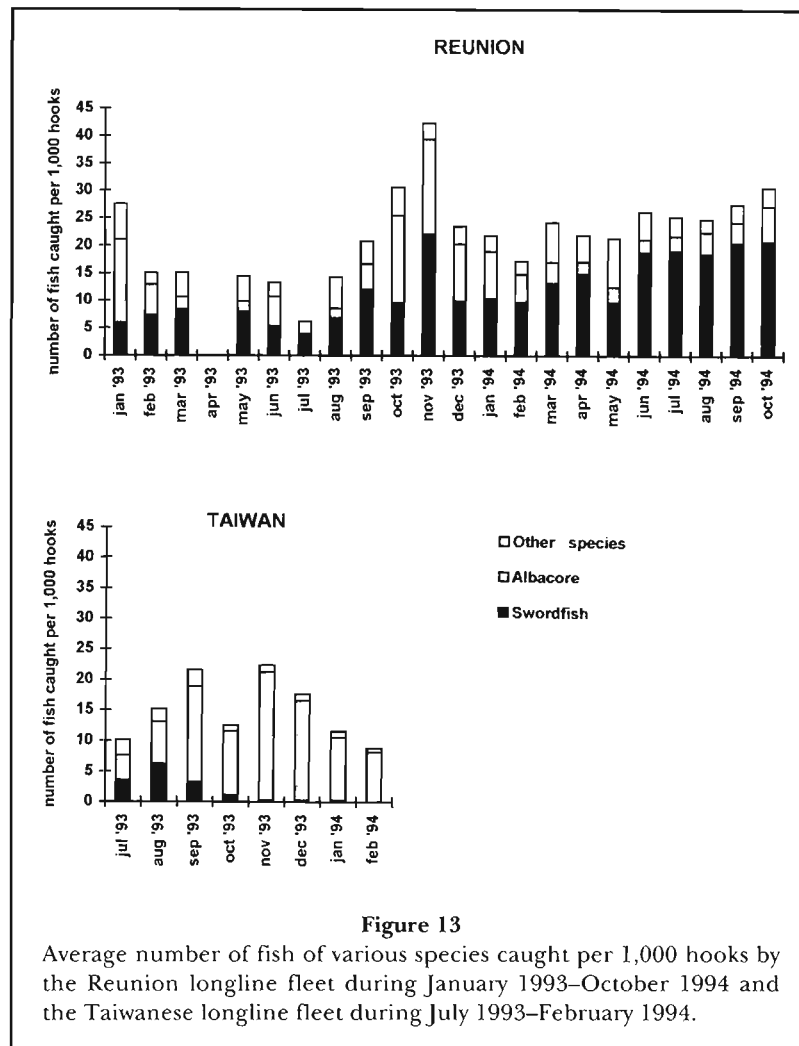
Typical swordfish management problems are linked with the dangers of local overexploitation (which should be controlled at a EEZ and subregional level) in conjunction with global ocean problems, which should be addressed by a future ad hoc Indian Ocean Tuna Commission.

Effective control of the longlining fleet should be set up through a number of geographically-limited subregional organizations to manage migratory and long-lived species such as swordfish. Only geographically limited organizations are likely to efficiently exert control and to be able to enforce edicts of the larger Indian Ocean Commission. Cooperation will become more crucial as the catch by the Taiwanese fleet continues to increase sharply, with no clear control either inside or outside the EEZ's of southwestern Indian Ocean countries.



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