# INFORMATION ON THE INDIAN OCEAN SWORDFISH STOCK FROM TAIWANESE TUNA CATCH STATISTICS AND ESTIMATION OF ITS ABUNDANCE INDEX (DRAFT)

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## THE FISHERY AND SWORDFISH CATCH

Taiwan's deep-sea longline fishery commenced in the mid-1950s, firstly in the North and East Indian Ocean and expanded extensively to the three major oceans. During late 1960s to the early 1970s, the main catch in the Indian Ocean was yellowfin tuna (Fig. 1). Later the main target species was shifted to albacore. Since 1980s, some of the longliners, together with newly built larger vessels with super cold freezers (below -60°C), started to shift their target to bigeye and yellowfin tunas. Besides of the three main tuna species, swordfish has also become a seasonal target species to some of the vessels since 1990s.

Annual catch of swordfish was less than 2,000 ton before 1985 and increased to 3,000 to 5,000 ton during 1986-1991 (Fig. 1). The 1992 catch was 9,000 ton and thereafter the catch was higher than 12,000 ton, with the record of 18,000 ton in 1995. The catch has decreased recently to about 13,000 ton in 2002. The catch history could be thus divided into three periods: before 1985 with low catch, 1986-1991 with median catch, and after 1992 with high catch.

The following sections provide some catch information on swordfish from Taiwanese longline catch and effort data (compiled from logbooks), as well as size data. Some preliminary standardization runs on its CPUE are also provided. The 2001 data is still considered preliminary due to incomplete logbook information.

## ANNUAL AND QUARTERLY CATCH AND CPUE DISTRIBUTION

Fig. 2 shows average swordfish catch distribution by decades in the Indian Ocean. It needs to be reminded that the weight scale of 1990s and 2000s is ten times higher than that of 1970s and 1980s. Swordfish catch was noted firstly in the Bay of Bangkok and the southwest waters off Madagascar in 1970s, and then gradually expanded to tropical area and southern temperate area in 1980s. During 1990s and 2000s when swordfish catch was significantly increased, major catches were noted in the waters from southern of 10°N in the western tropical area to the southern waters off Madagascar.

The catch distribution patterns were different among quarters (Fig. 3). In the first quarter, comparatively higher catch was noted in the northern area of 10°S. In the second quarter an extra high catch area was noted in the southern area between 30°S and 40°S. And then in the third quarter, the northern high catch area moved southwards and the southern high catch area moved northwards. The two areas seemed joined together in the fourth quarter.

The quarterly catch distribution pattern in the two periods: before 1990s and since 1990s, were similar as a whole, except that the latter one was more expanded. The fishing ground around Madagascar seemed to exist all the four quarters since 1990s.

Catch composition of swordfish to the four main target species by decades is shown in Fig. 4. Yellowfin tuna and albacore were the major species caught in 1970s. Catch composition of bigeye became high in 1980s. And then swordfish catch composition became more evident in 1990s and 2000s in the area where its catch was significant in Fig. 2.

As to nominal CPUE (kg/1000 hooks), the area with high CPUE was more restricted before 1990s (Fig. 5). However since 1990s, high CPUE areas were much more obvious in four regions: the traditional area of Bay of Bangkok, the coastal area of

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Somalia, the southern and western area of Madagascar, and the eastern area of Australia.

Quarterly pattern of the CPUE distribution was not so clear comparing to the catch distribution (Fig. 6). Roughly however it has a similar pattern as of the quarterly catch distribution, and the high CPUE in the Madagascar waters and the eastern Australia waters were more evident since 1990s than before 1990s.

**TREND OF CATCH, CPUE AND MEAN WEIGHT**

Swordfish catch in all the four quarters have shown an increasing trend after 1985 (Fig. 7). The catch was steadily increasing in the first quarter after 1985, and dramatically increased in the third quarter of 1992, in the forth quarter of 1993, and in the second quarter of 1995. Most of the swordfish catch was made in the third quarter since 1992. About or more than 5,000 ton of catch was made in the third quarter during recent years.

Base on catch distribution and catch composition by years, ten areas (regions) were defined in Fig. 8. The catch trend of the ten areas is shown in Fig. 9 (the scales are different among areas). Some areas showed continuous increasing trend, especially Area 4 which might be relating to the development of tuna fishery. Some other areas showed a significant increasing trend after 1985. The increases in Area 3 (off Somalia) and Area 7 (off Madagascar) contribute most to the increase of annual catch in the period after 1992.

Nominal CPUE of the four quarters also showed an increasing trend after 1985 (Fig. 10). The increasing is much more significant in the third quarter than the rest periods.

The mean weight (Fig. 11) calculated from catches in weight and in number from the logbooks, has been decreasing from 1970s and stabilized at 60 to 70 kg in 1990s in the first quarter. Similar trend was shown in the second quarter, stabilized at the same level as in 1980s and 1990s. Mean weight in the third quarter was fluctuated between 60-70 kg and stayed at the level about 65-70 kg in 1990s. For the forth quarter, it was fluctuated at 55-70 kg all the time period.

**LENGTH FREQUENCY**

Fishers were requested to report size measurements of the first 30 fish of each day’s catch. Since swordfish is not a target species all the periods and due to that it is more difficult to measure it, the number of measurements was small and has not covered the whole catch area. As a whole, the size was in the range of 120-200 cm with mode of 140-170 cm and mean length of 140-160 cm during 1980 to 2001 (Fig. 12).

Fig. 13 shows the annual trends of mean length and mean weight. Broadly the trends were coincident between the two series. But for the recent two years the mean length become smaller while the mean weight from logbook was stable. This might resulted from the incomplete length sampling.

**CPUE STANDARDIZATION**

The CPUE of swordfish was standardized under lognormal model approach. The statistical models applied was the standard Generalized Linear Model (GLM) with main factors of year, quarter, area and target effects. CPUE in the model was calculated in terms of weight as kg per 1000 hooks, as were used in ICCAT. Area stratification (10 areas) was done based on the catch distributions, as shown previously in Fig. 8. Since too few data was available for the procedure, Area 2 was removed from the final runs.

Interactions among factors were considered in the GLM, but the insignificant interaction terms (P=99%) were removed from the final model. Dependant variable of the model was calculated as logarithm of the CPUE plus 10% of its grand mean.

The trend of swordfish catch and CPUE was related with the shift of target species. Due to insufficient information of hooks per basket (HPB), the target effect was expressed by quartile of the catch rates of the other three target species, i.e., albacore, bigeye and yellowfin tunas. A catch proportion ranking approach (Takeuchi, personal comm.) was also used as target effect in the standardization: The proportion of albacore, bigeye and yellowfin catches in the total, respectively, were calculated in percentage for monthly 5x5 blocks and attached ranking for them from the higher percentage to lower. Those ranking were then categorized into four classes. The third trial to express the target effect was the quartile of the catch composition of swordfish to all the species caught (excluding sharks, skipjack and other fish).

Table 1 shows the statistics of the GLM runs from SAS program of the three options on target effects. Fig. 14 plots the nominal and standardized CPUE of the three options. All the three standardized trends showed a higher level of CPUE in 1990s and stabilized thereafter (note: the 2001 data is preliminary due to incomplete logbooks).

From current results, the target effect might have not been interpreted completely. Further studies may be needed on the definition of target effect in GLM approaches. Separating the plausible targeting area and season from non-targeting one for an independent standardization may also be worthwhile for consideration in the future.

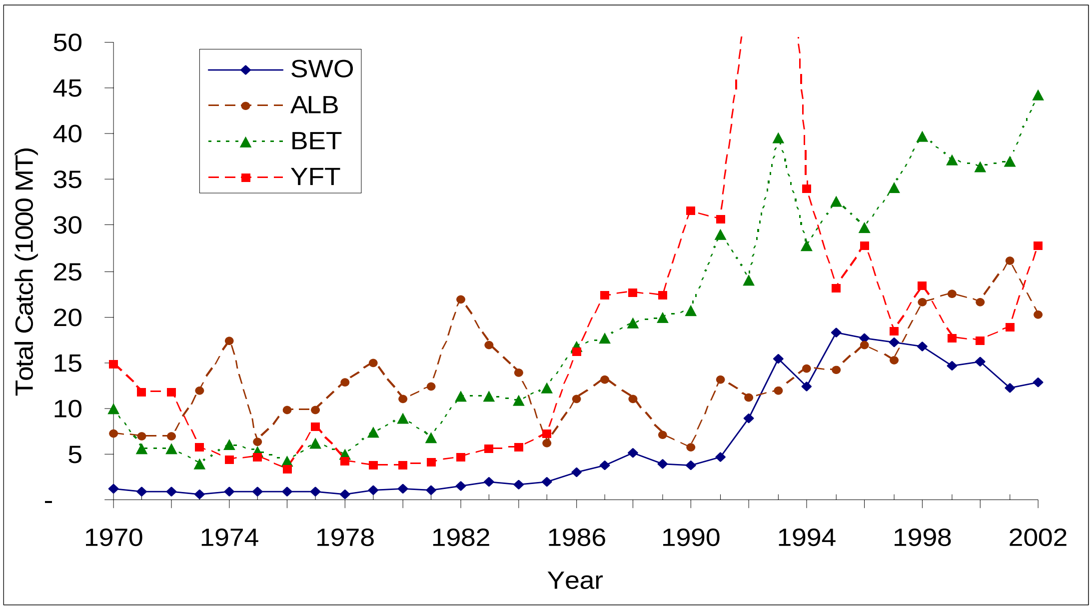



*Fig. 1. Annual catches of the major tunas (ALB, BET, YFT) and swordfish (SWO) of the Indian Ocean by Taiwanese longline fishery, 1970-2002. YFT catch of 1993 is omitted.*

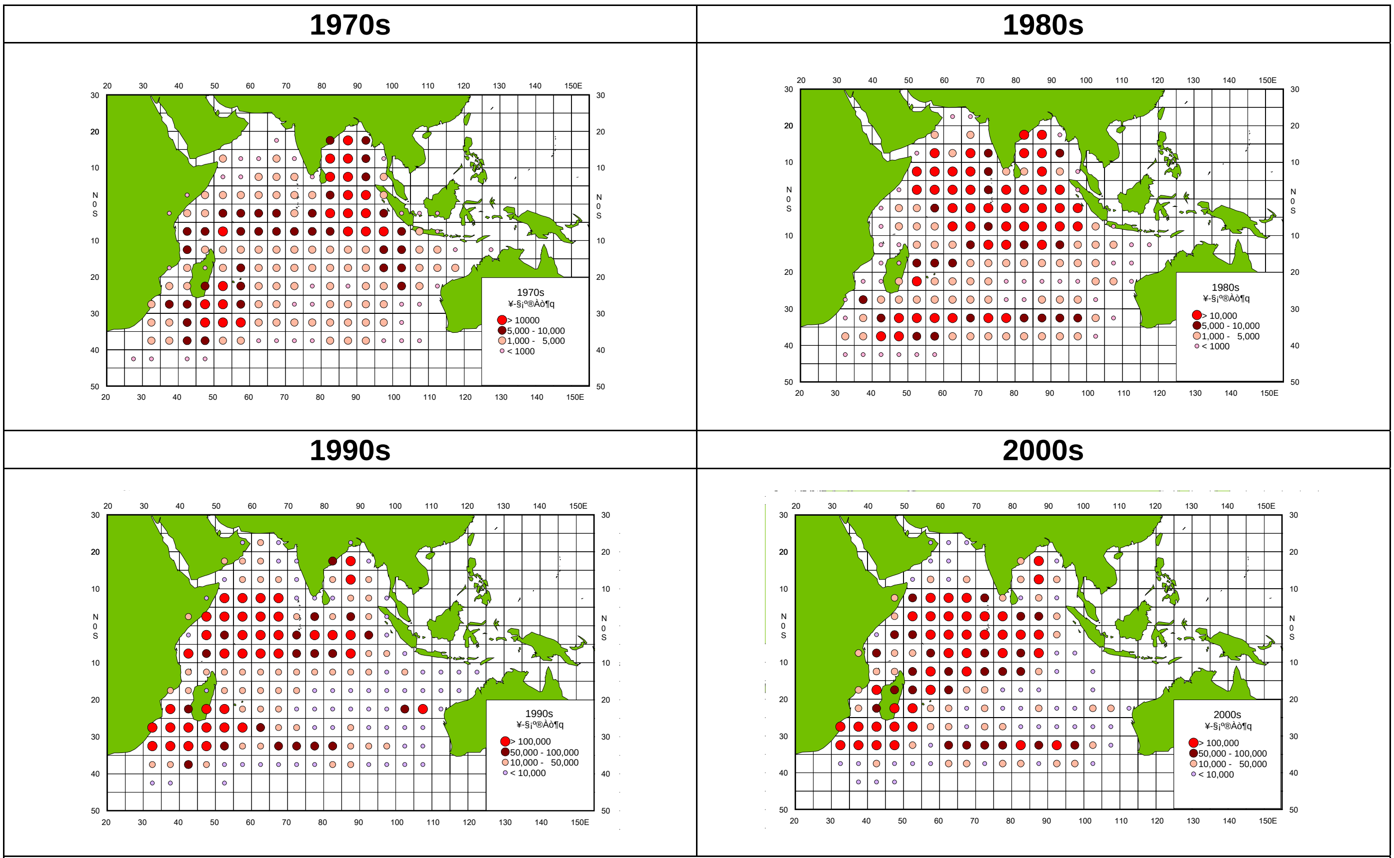
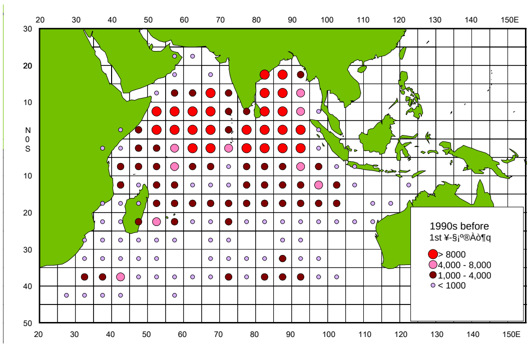



*Fig. 2. Annual average swordfish catch distribution by decades during 1970-2002, by Taiwan longline fishery. Note the scales of 1990s and 2000s are ten-times of those of 1970s and 1980s.*

**Before 1990s Q-1**

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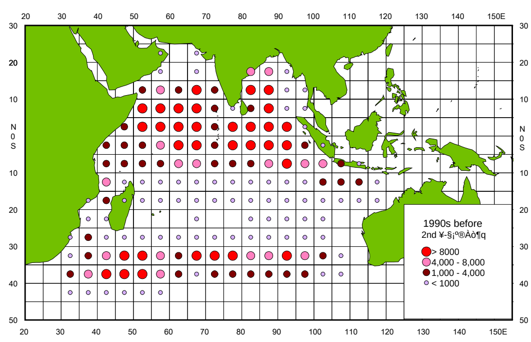


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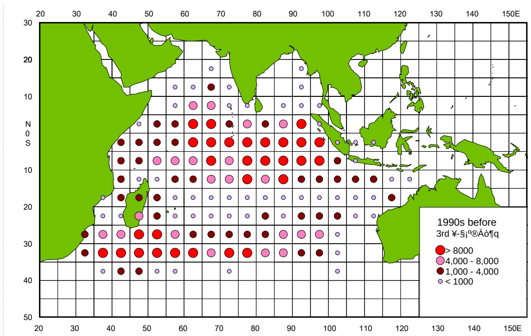


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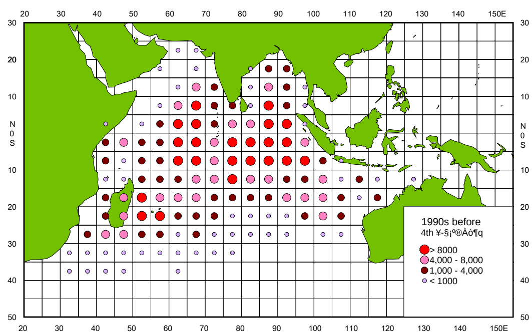
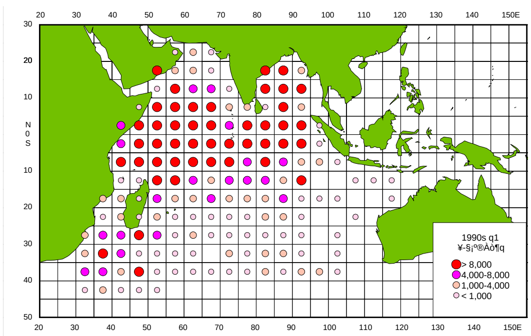



**1990s and 2000s Q-1**

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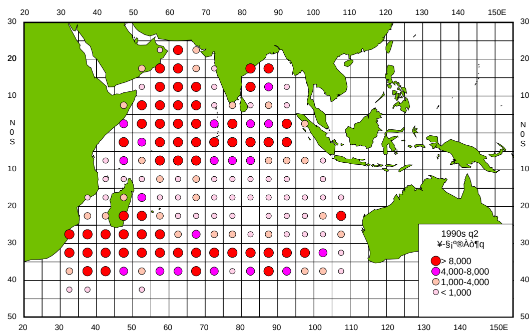


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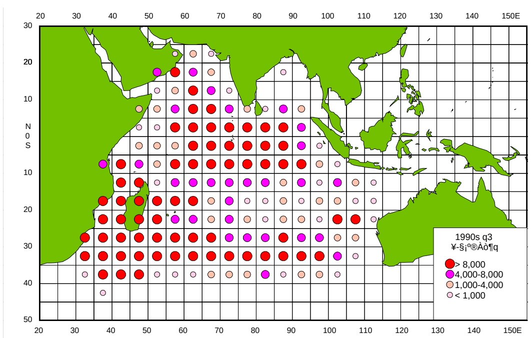


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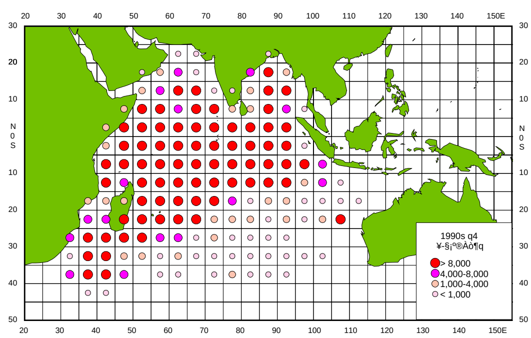



*Fig. 3. Annual average swordfish catch distribution by quarter for the period before 1990s and since 1990s, by Taiwan longline fishery.*

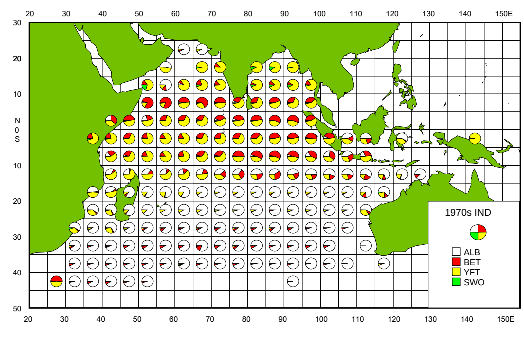
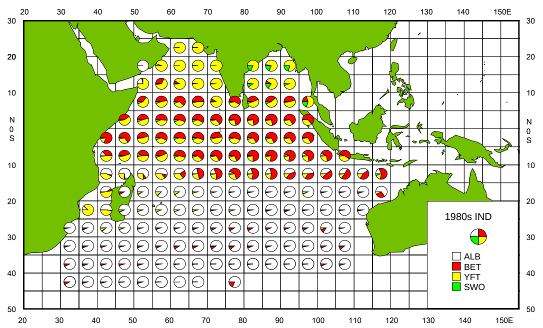
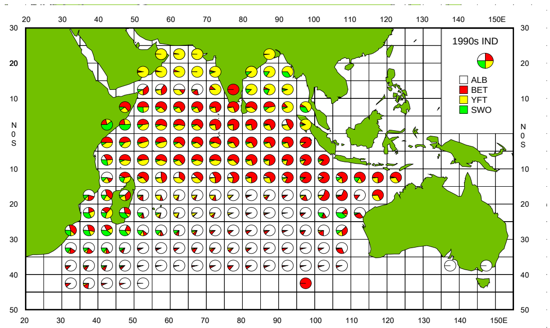
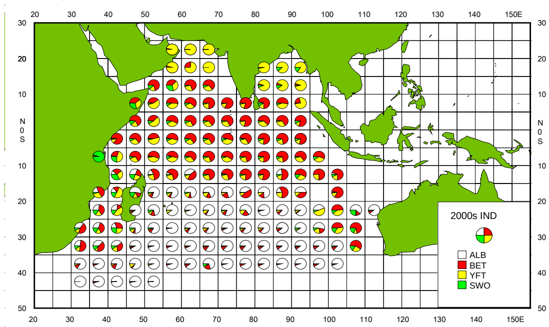
| 1970s | 1980s |
| --- | --- |
|  |  |
| **1990s** | **2000s** |
|  |  |



*Fig. 4. Catch composition of the four main species by decades*

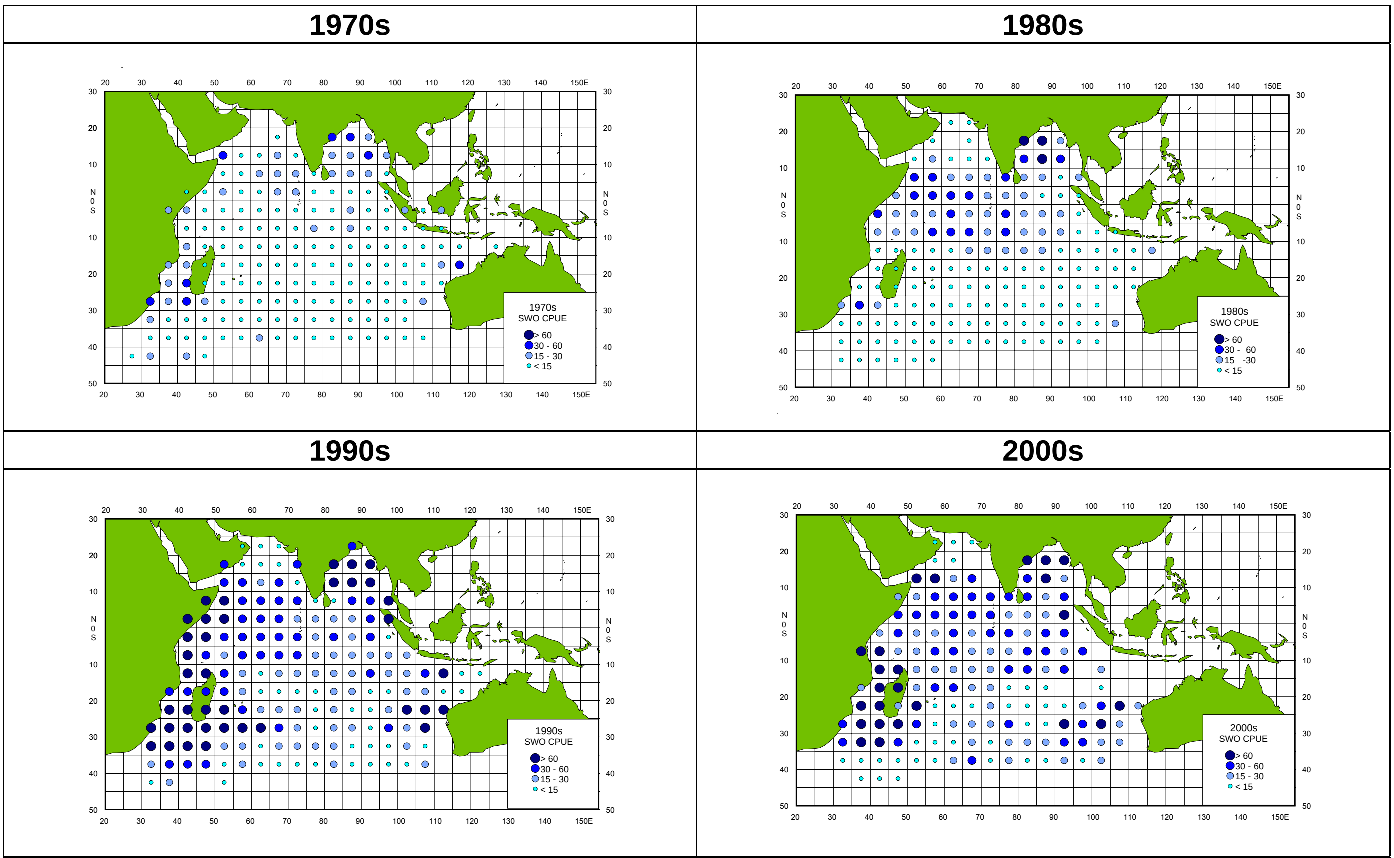



*Fig. 5. CPUE (kg/1000 hooks) distribution of swordfish by decades.*

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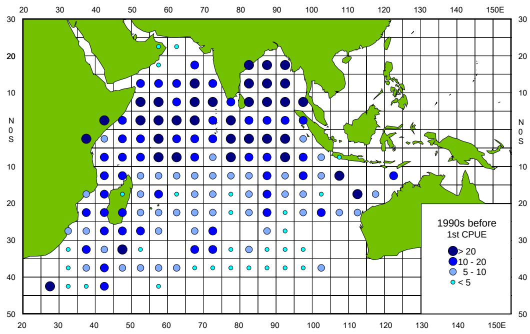


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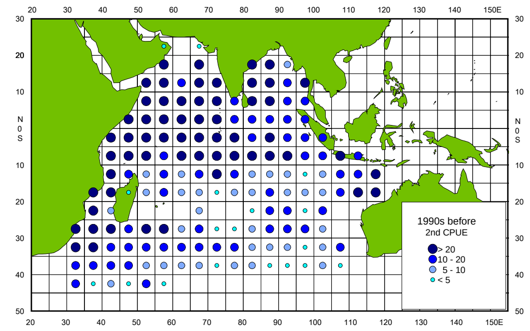


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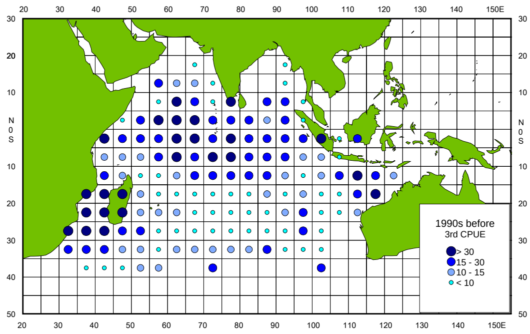


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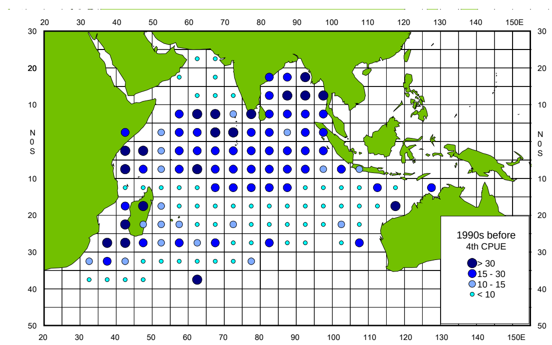
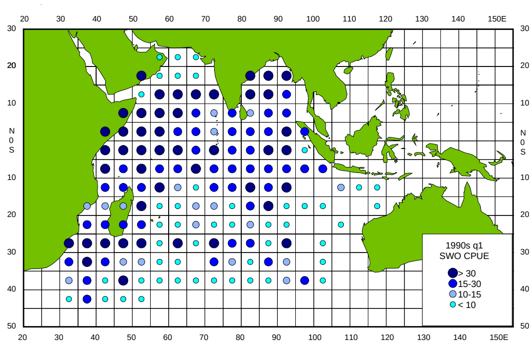



**1990s and 2000s Q-1**

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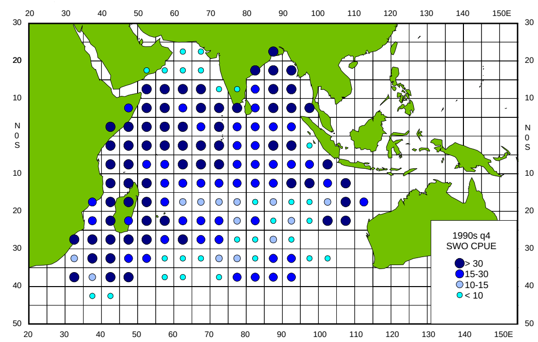


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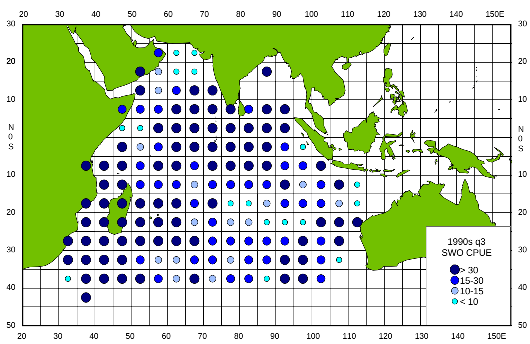


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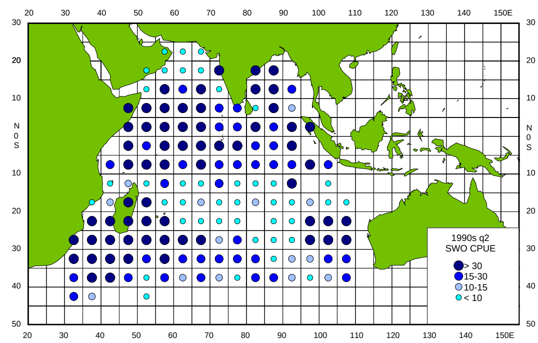


Fig. 6. CPUE distribution of swordfish by quarter for the period before 1990s and since 1990s, by

Taiwan longline fishery.

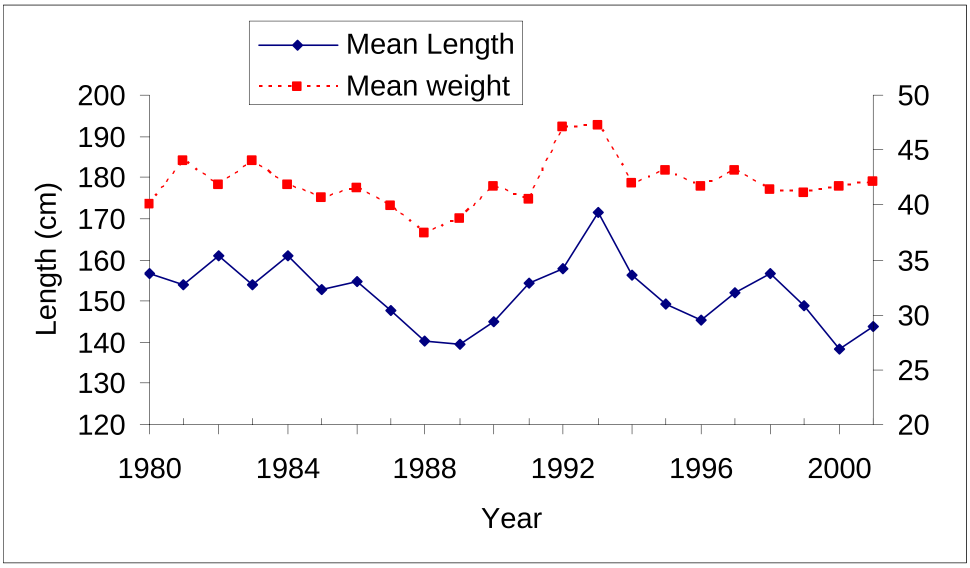


*Fig. 13. Time series of mean length and mean weight of swordfish from Taiwan longline catch data, 1980-2001.*

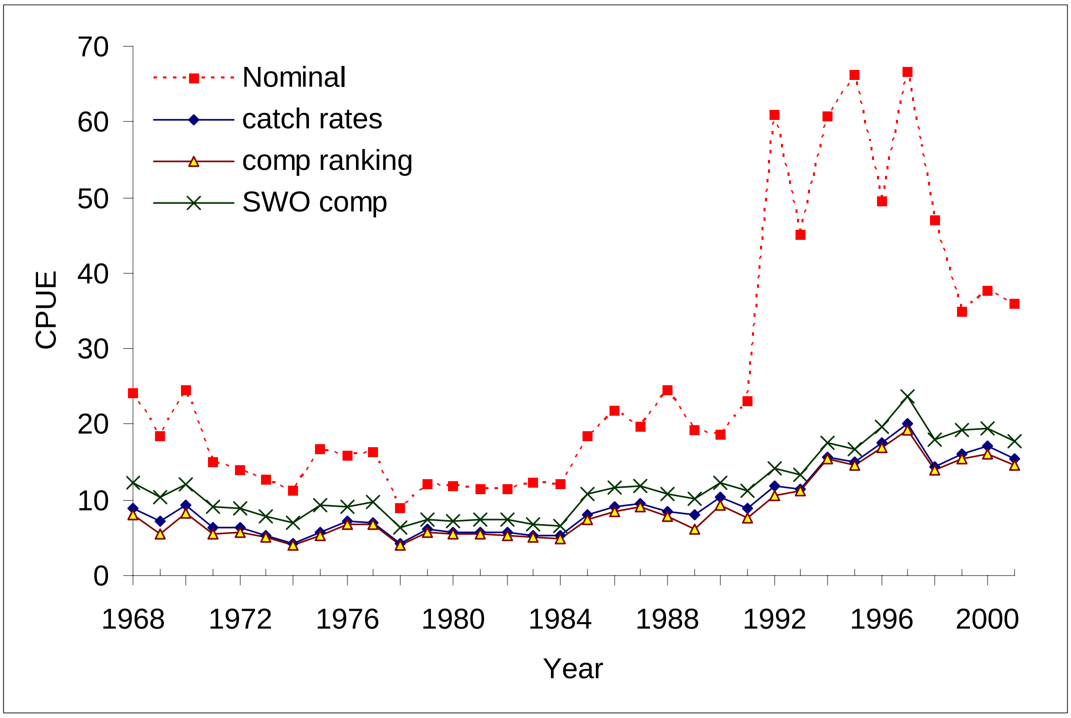


*Fig. 14. Standardized CPUE series from GLM runs for three options to express target effects: using the quartile of catch rates of the main tunas (albacore, bigeye and yellowfin), the catch composition ranking for the main tunas, and the quartile of swordfish catch composition.*