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AVAILABILITY OF OBSERVER DATA FOR ESTIMATING CATCHES OF NON-TARGET SPECIES BY LONGLINERS IN THE WESTERN AND CENTRAL PACIFIC OCEAN, WITH CATCH ESTIMATES FOR OFFSHORE FLEETS IN TROPICAL WATERS

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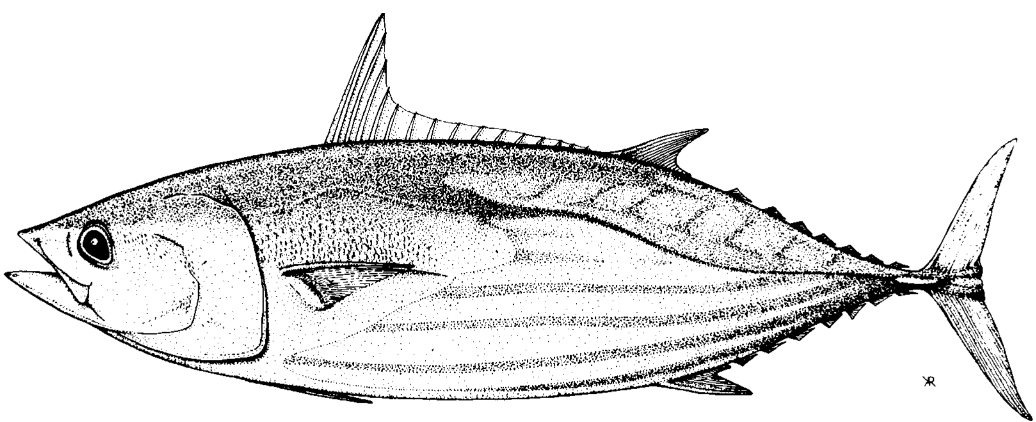

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INTRODUCTION

The availability of observer data held by the SPC Oceanic Fisheries Programme for estimating catches of non-target species by longliners in the Western and Central Pacific Ocean is considered. For this purpose, the longline data held by the OFP have been categorised as follows:

- The ‘distant-water, bigeye and yellowfin’ category includes the distant-water longliners of Japan, Korea and Chinese Taipei that have targeted bigeye and yellowfin.
- The ‘distant-water, albacore’ category includes Chinese Taipei distant-water longliners that have targeted albacore.
- The ‘offshore, tropical waters’ category includes offshore longliners of China, Federated States of Micronesia, Kiribati, Marshall Islands, Papua New Guinea, Solomon Islands, Chinese Taipei, United States of America (excluding American Samoa and Hawaii) and Vanuatu that have targeted bigeye and yellowfin between 15°N and 15°S.
- The ‘offshore, albacore’ category includes offshore longliners of American Samoa, Cook Islands, Fiji, French Polynesia, New Caledonia, Samoa and Tonga that have targeted albacore.
- The ‘Australia’, ‘Indonesia’, ‘New Zealand’ and ‘Philippines’ categories includes the domestic longliners of those countries.
- The ‘Chinese Taipei, offshore, domestic’ category includes offshore longliners of Chinese Taipei that operate to the west of 130°E, most of which are based in Chinese Taipei.
- The ‘United States, Hawaii’ category includes United States longliners based in Hawaii.
- The ‘Other’ category is for longline data that are not included in the categories above and primary covers offshore longliners targeting bigeye and yellowfin that have fished north of 15°N and south of 15°S.

Following consideration of the availability of data, estimates of catches by the ‘offshore, tropical waters’ category during 1998–2001 are presented and discussed.

AVAILABILITY OF OBSERVER DATA FOR ESTIMATING CATCHES OF NON-TARGET SPECIES BY LONGLINERS

Total longline effort

Table 1 compares total longline effort among fleet categories and time periods. The statistics represent annual averages for each of the 6 five-year periods from 1970 to 1999 and the three-year period from 2000 to 2002. The following points are of interest:

- While the percentage of the total effort by the ‘distant-water, bigeye and yellowfin’ category has declined over the time series, it still represented 39.8% of total effort during 2000–2002.
- The amount of effort by the ‘distant-water, albacore’ category has increased in recent years, although the proportion of the total has remained less than 10%.

- Effort by the ‘offshore, tropical waters’ and ‘offshore, albacore’ fleets has increased considerably from the early 1990s onwards and represented 19.1% and 9.3% of the total, respectively, during 2000–2002.

Observed longline effort

Table 2 compares the observed longline effort, by fleet category and time period:

- During 1990–1994, 91.7% of observed effort was for the ‘distant-water, bigeye and yellowfin’ category. During 1995–1999, coverage of this category declined and during 2000–2002, it represented only 4.9% of the total coverage. The drop in coverage is related to the cessation of fishing by the Japanese distant-water longline fleet in the waters of Australia in 1998 and New Zealand in 1999.

- During 1995–1999, coverage of the offshore fleets increased. During 2000–2002, coverage of the ‘offshore, tropical waters’ and ‘offshore, albacore’ categories represented 44.3% and 14.3% respectively of the total coverage. The increase in coverage is related to the establishment of observer programmes in SPC member countries and territories.

- Coverage of the ‘United States, Hawaii’ category commenced in 1994 and represented 24.7% and 36.3% of the total coverage during 1995–1999 and 2000–2002 respectively.

Observer coverage rates and number of sets covered

Table 3 presents observer coverage rates, by fleet category and time period:

- Coverage during 1970–1974, 1975–1979 and 1980–1984 was nil. During 1985–1989, only the ‘distant-water, bigeye and yellowfin’ category was covered and the level of coverage was negligible.

- During 1990–1994, 1995–1999 and 2000–2002, observer coverage averaged only 0.57%, 0.62% and 0.49% of total fishing effort per annum respectively.

- Observer coverage has been less than 5% for all categories and time periods, and has been less than 1% for all categories and time periods except the ‘United States, Hawaii’ category since 1994, the ‘New Zealand’ category during 1995–1999, the ‘offshore, tropical waters’ category during 2000–2002, and the ‘other’ category.

Table 4 presents the number of sets covered by observers, by fleet category and time period. It should be noted that:

- While the coverage rate of the ‘distant-water, bigeye and yellowfin’ category has been less than 1% (Table 3), the number of sets covered is relatively high for 1990–1994 and 1995–1999. However, most of these sets were observed in the waters of Australia and New Zealand (Table 5). Excluding the data from Australia and New Zealand, the average annual number of sets covered was relatively low, 42 during 1995–1999 and 53 during 2000–2002, and the number of sets covered during other periods was nil. Apart from the waters of Australia and New Zealand, the areas covered consist of the economic zones of Kiribati (1998 and 2002), New Caledonia (1995 and 1996) and Solomon Islands (1996 and 1998–2001), whereas the fishing effort by this category extends over the whole WCPO, including broad areas of the high seas for which almost no observer data are available. All data for this category cover the Japanese longline fleet, except for three trips covering Korean longliners in the waters of Kiribati; no data are available covering the Taiwanese distant-water longliners that have targeted bigeye and yellowfin.

- The 'distant-water, albacore' category was covered by an average of 20.4 sets annually during 1995–1999 (Table 4). In fact, all 102 sets were observed on the same vessel during the same trip and, hence, cover a limited geographic area and time period.

- The 'offshore, tropical waters' category was covered by an average of 54.6 sets annually during 1990–1994 (Table 4). In fact, 83 sets were observed during 1993 and 182 sets were observed in 1994; no sets were observed during 1990–1992.

- While the average annual coverage rate for the 'Other' category has been greater than 1%, the annual number of sets covered has averaged only 1.4 and 2.3 during 1995–1999 and 2000-2002 respectively.

Availability of observer data

The availability of observer data held by the OFP that can be used to obtain meaningful estimates of catches of non-target species by categories of longliners in the Western and Central Pacific Ocean can be summarised as follows:

- Observer data covering the 'distant-water, bigeye and yellowfin' category may be sufficient for estimating catches of non-target species in limited geographic areas and time periods, such as the waters of Australia during 1991–1998 and New Zealand during 1987–1999. But due to incomplete coverage in regard to geographic area, time period and vessel flag, they are not considered sufficient for estimating the catches of non-target species by this category for the whole of the WCPO.

- Observer data for the 'distant-water, albacore' category consist of only one trip and, hence, are insufficient for estimating catches of non-target species.

- Observer data for the 'offshore, tropical waters' category may be sufficient for estimating catches of non-target species during 1993–2002.

- Observer data for the 'offshore, albacore' category may be sufficient for estimating catches of non-target species during 1995—2002.

- Observer data held by the OFP for the 'New Zealand' category, which cover domestic vessels, may be sufficient for estimating catches of non-target species during 1995–1999; data for subsequent years have not yet been provided to the OFP.

- Observer data held by the OFP for the 'United States, Hawaii' category may be sufficient for estimating catches of non-target species during 1994–2002; data for subsequent years have not yet been provided to the OFP.

- Observer data for the 'Other' category are insufficient; however, effort by the 'Other' category is negligible.

- No observer data are held by the OFP for the longline fleets of Australia, Indonesia, Philippines and Taiwan (offshore, domestic). However, Australia has recently commenced an observer programme covering domestic longliners.

Evaluation of data quality

The availablity of observer data summarised above assumes that the quality of the data held by the OFP is such that they can be used for estimating catches of non-target species. In order to determine whether this is indeed the case, the OFP recently evaluated the observer data provided by certain SPC member countries and territories for 1998–2001 in regard to several criteria that will affect estimates of catches of non-target species, primarily species identification. (The observer data for other years will be evaluated in due course.)

For the ‘offshore, tropical waters’ category, the data for 984 out of 1,208 sets observed during 1998–2001 (81.4%) were found to be of acceptable quality. For each year from 1998 to 2001, the number of sets for which the data are acceptable is 257, 177, 284 and 266 respectively. While the number of observed sets with acceptable data is considerably less than the total number of observed sets, the acceptable data are still considered sufficient for estimating catches of non-target species during this period.

For the ‘offshore, albacore’ category, data for 163 out of 257 sets observed during 1998–2001 (63.4%) were found to be of acceptable quality. For each year from 1998 to 2001, the number of sets for which the data are acceptable is 36, 88, 25 and 14 respectively. Much less acceptable data are available for the ‘offshore, albacore’ category than for the ‘offshore, tropical waters’ category and the former are not considered sufficient to estimate annual catches of non-target species during this period.

ESTIMATION OF CATCHES OF NON-TARGET SPECIES BY OFFSHORE LONGLINERS IN TROPICAL WATERS

Annual catches of non-target fish species taken by offshore longliners targeting yellowfin and bigeye in tropical waters were estimated as the product of the catch rate and fishing effort. The catch rate was determined from observer data held by the OFP that were evaluated to be of acceptable quality. Fishing effort during 1998–2001 (Table 6) was determined from operational catch and effort held by the OFP that have been raised to represent total catch and effort for each vessel flag. Catches were estimated for all flags combined. Catches of target species were estimated for comparison with statistics based on commercial data. Catches for the aggregate period 1998–2001 were estimated as the product of the catch rate determined from all observer data for the period combined, and the average fishing effort.

Fishing effort was assumed known without error; therefore, the coefficient of variation of the catch was estimated as the coefficient of variation of the catch rate. An approximation of the coefficient of variation of the catch rate (CV), for each fleet category–year stratum, was determined from sampling theory (Cochran 1977) as follows:

$$CV = \frac{\sqrt{V(\hat{U})}}{U} \cong \frac{\sqrt{1-r}}{\sqrt{n}} \cdot \frac{\sqrt{\dfrac{\sum_i^N (c_i - Ue_i)^2}{N-1}}}{\overline{C}}, \qquad (1)$$

where U and $\hat{U}$ are the true catch rate and estimated catch rate; $V(\hat{U})$ is the variance of $\hat{U}$; r is the observer coverage rate, $\frac{n}{N}$; N and n are the total number of sets and the number of observed sets;

c_i and e_i are the catch and effort for the i^th observed set; and $\overline{C}$ is the true average catch per set. The observer data were used to approximate $\sqrt{\frac{\sum_i^N (c_i - Ue_i)^2}{N-1}}$ and $\overline{C}$; the sample estimate of $\sqrt{\frac{\sum_i^N (c_i - Ue_i)^2}{N-1}}$ has a bias of order $\frac{1}{n}$.

RESULTS AND DISCUSSION

Catch estimates for the 'offshore, tropical waters' longline fleet category, for each year from 1998 to 2001 and the aggregate period 1998–2001, are presented in Table 7. Catch rates are presented in Table 8.

Species composition

Tables 9 and 10 summarise the species composition. During 1998–2001, catches taken by the 'offshore, tropical waters' category consisted of 65.9% tunas, 10.0% billfish, 21.1% sharks and rays, and 3.1% other fish. The species composition for individual years has varied without trend about the aggregate 1998–2001 values.

Factors affecting the coefficients of variation

The coefficients of variation in Table 7 vary widely, as might be expected from equation (1). The coefficients of variation given by equation (1) are composed of four factors. The first and second factors, $\sqrt{1-r}$ and $\frac{1}{\sqrt{n}}$, depend on the observer coverage rate and the absolute number of observed sets respectively. The third factor, $\sqrt{\frac{\sum_i^N (c_i - Ue_i)^2}{N-1}}$, is the standard deviation of the difference between the observed catch per set and the catch per set predicted by the product of the observed effort per set and the average catch rate. When the variation in the catch rate among sets is high, then this factor, and hence the coefficient of variation, will be large. The fourth factor, $\overline{C}$, is the average catch per set. For species with a relatively high average catch per set, the coefficient of variation will be relatively small. Conversely, for species with a relatively low average catch per set, the coefficient of variation will be relatively large.

Table 11 presents the relative contributions of the different factors to the coefficients of variation of the estimates of the catch of all species combined, for each year. (The catches and catch rates in factors 3 and 4 are expressed in terms of kilograms, rather than numbers of fish.) The observer coverage rate is consistently low; hence, factor #1 is consistently near 1.0. The numbers of sets observed per annum are similar; hence, factor #2 varies by only a small amount. Factor #3, which depends on the variation in the catch per set, varies the most, within the largest value being equal to 350% of the smallest value. Factor #4, the average catch per set, varies moderately, with the largest value being equal to 182% of the smallest value.

While the coefficients of variation for the estimates of the catches of all species combined are relatively small (less than 10%), the coefficients of variation for the individual species are generally much larger and, hence, the variation in factors #3 and #4 will be even greater.

Coefficients of variation based on sampling theory versus sub-sampling

Lawson (2004) showed that for unstratified sampling, equation (1) gives coefficients of variation that are almost identical to sub-sampling, whereas for stratified sampling, equation (1) may under-estimate the coefficient of variation due to the lack of independence among strata. The estimates in Table 7 have been stratified by year and so coefficients of variation based on sub-sampling should be considered and compared to those based on sampling theory. Stratification based on vessel flag, and flag and year, should also be considered, although it is expected that the number of observed sets for many strata of flag–year will be too small to obtain meaningful catch estimates.

Catch estimates for target species based on observer data versus commercial data

Tables 12 and 13 compare catch rates and catch estimates determined from observer data and commercial data (e.g., unloadings data and catch and effort logsheets), for bigeye and yellowfin caught by the 'offshore, tropical waters' fleet category during 1998–2001.

Bigeye catch rates (in kg per 100 hooks) and annual catches based on observer data are 43.2% greater than those based on commercial data, while yellowfin catch rates and catches are 62.9% greater. For bigeye, the differences for individual years range from –15.7% to +82.5% (Table 12), while for yellowfin, the differences range from +19.7% to +80.2% (Table 13).

Discards of target species represent only a small percentage of the total catch; hence, the fact that discards are covered by the observer data does not account for the differences.

The manner in which average weights are used to convert logsheet catch data and observer catch data from units of number of fish to kilograms are similar; hence, the differences in Tables 12 and 13 for catch rates in units of kilograms per 100 hooks are generally similar to the differences in units of number of fish per 100 hooks. Only a portion of the differences in catch rates in units of kilograms per 100 hooks and catches can therefore be explained by differences in the average weights used for observer data and commercial data.

There are thus large, unexplained differences between catch rates based on observer data and commercial data. These differences may be related to a lack of representativeness of the observer data and/or the commercial data in regard to the vessel flags, geographic areas or time periods covered. While coverage of the observer data is, in general, much less than the commercial data, the representativeness of both types of data should be examined in detail. Until the inconsistencies between the observer data and the commercial data are resolved, the catch estimates for non-target species in Table 7 should be considered as preliminary.

The commercial data should also be examined in regard to variation in reported catch rates related to the presence or absence of observers onboard the vessel. Since the reporting of commercial data may be affected by the presence of an observer, it will not suffice to compare catch rates determined from observer data to catch rates based on commercial data for fishing trips for which both types of data are available. Catch rates determined from commercial data for vessels with observers should be compared to those for vessels without observers, within strata of flag, area and time period.

REFERENCES

Cochran, W.G. 1977. Sampling Techniques, Third Edition. John Wiley & Sons, New York, New York.

Lawson, T. 2004. Observer coverage rates and reliability of CPUE estimates for offshore longliners in tropical waters of the Western and Central Pacific Ocean. Working Paper SWG–4. Seventeenth Meeting of the Standing Committee on Tuna and Billfish, 9–18 August 2004, Majuro, Marshall Islands. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia.

Table 1. Average annual longline effort (million hooks), by fleet category

Fleet Category	1970-1974		1975-1979		1980-1984		1985-1989		1990-1994		1995-1999		2000-2002	
	Hooks	%	Hooks	%	Hooks	%	Hooks	%	Hooks	%	Hooks	%	Hooks	%
Distant-water, bigeye and yellowfin	259.64	84.7	262.05	76.9	306.51	74.1	280.82	73.4	236.93	59.9	206.81	46.5	227.77	39.8
Distant-water, albacore	18.40	6.0	27.34	8.0	28.00	6.8	22.94	6.0	38.05	9.6	34.87	7.8	54.22	9.5
Offshore, tropical waters	-	-	-	-	0.59	0.1	2.58	0.7	35.45	9.0	74.57	16.8	109.63	19.1
Offshore, albacore	-	-	-	-	0.43	0.1	1.58	0.4	6.13	1.6	21.89	4.9	53.39	9.3
Australia	-	-	-	-	-	-	1.68	0.4	9.66	2.4	7.72	1.7	11.27	2.0
Indonesia	-	-	0.83	0.2	4.60	1.1	14.67	3.8	21.35	5.4	32.96	7.4	61.76	10.8
New Zealand	-	-	-	-	-	-	-	-	2.42	0.6	5.59	1.3	10.45	1.8
Philippines	1.64	0.5	1.68	0.5	3.83	0.9	6.97	1.8	5.05	1.3	6.03	1.4	11.00	1.9
Chinese Taipei, offshore, domestic	26.77	8.7	49.08	14.4	69.29	16.8	51.53	13.5	30.90	7.8	38.85	8.7	10.97	1.9
United States, Hawaii	-	-	-	-	-	-	-	-	9.60	2.4	15.85	3.6	22.12	3.9
Other	-	-	-	-	0.16	0.0	0.01	0.0	0.01	0.0	0.11	0.0	0.36	0.1
Total	306.44	100.0	340.98	100.0	413.41	100.0	382.77	100.0	395.56	100.0	445.24	100.0	572.94	100.0

Table 2. Average annual observed longline effort (million hooks), by fleet category

Fleet Category	1970-1974		1975-1979		1980-1984		1985-1989		1990-1994		1995-1999		2000-2002	
	Hooks	%	Hooks	%	Hooks	%	Hooks	%	Hooks	%	Hooks	%	Hooks	%
Distant-water, bigeye and yellowfin	-	-	-	-	-	-	0.08	100.0	2.07	91.7	1.28	46.7	0.14	4.9
Distant-water, albacore	-	-	-	-	-	-	-	-	-	-	0.06	2.1	-	-
Offshore, tropical waters	-	-	-	-	-	-	-	-	0.07	3.2	0.43	15.6	1.23	44.3
Offshore, albacore	-	-	-	-	-	-	-	-	0.00	0.1	0.14	5.2	0.40	14.3
Australia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indonesia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Zealand	-	-	-	-	-	-	-	-	0.01	0.3	0.15	5.6	-	-
Philippines	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chinese Taipei, offshore, domestic	-	-	-	-	-	-	-	-	-	-	-	-	-	-
United States, Hawaii	-	-	-	-	-	-	-	-	0.11	4.7	0.68	24.7	1.01	36.3
Other	-	-	-	-	-	-	-	-	-	-	0.00	0.1	0.01	0.2
Total	0.00	-	0.00	-	0.00	-	0.08	100.0	2.25	100.0	2.75	100.0	2.79	100.0

Table 3. Average annual observer coverage rate (%), by fleet category

Fleet Category	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2002
Distant-water, bigeye and yellowfin	-	-	-	0.03	0.87	0.62	0.06
Distant-water, albacore	-	-	-	-	-	0.17	-
Offshore, tropical waters	-	-	-	-	0.20	0.57	1.13
Offshore, albacore	-	-	-	-	0.05	0.65	0.75
Australia	-	-	-	-	-	-	-
Indonesia	-	-	-	-	-	-	-
New Zealand	-	-	-	-	0.33	2.76	-
Philippines	-	-	-	-	-	-	-
Taiwan, offshore, domestic	-	-	-	-	-	-	-
United States, Hawaii	-	-	-	-	1.09	4.28	4.57
Other	-	-	-	-	-	2.78	1.69
Total	0.00	0.00	0.00	0.02	0.57	0.62	0.49

Table 4. Average annual number of observed sets, by fleet category

Fleet Category	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2002
Distant-water, bigeye and yellowfin	-	-	-	28.2	848.4	486.8	53.0
Distant-water, albacore	-	-	-	-	-	20.4	0.0
Offshore, tropical waters	-	-	-	-	54.6	314.0	683.7
Offshore, albacore	-	-	-	-	2.4	81.6	200.0
Australia	-	-	-	-	-	-	-
Indonesia	-	-	-	-	-	-	-
New Zealand	-	-	-	-	5.8	113.6	-
Philippines	-	-	-	-	-	-	-
Taiwan, offshore, domestic	-	-	-	-	-	-	-
United States, Hawaii	-	-	-	-	101.6	548.2	868.0
Other	-	-	-	-	-	1.4	2.3
Total	0.0	0.0	0.0	28.2	1,012.8	1,566.0	1,807.0

Table 5. Average annual number of observed sets for the ‘distant-water, bigeye and yellowfin’ fleet category, by observer programme

Observer Programme	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2002
Australia	-	-	-	-	603.4	205.4	-
Kiribati	-	-	-	-	-	10.8	33.0
New Caledonia	-	-	-	-	-	8.4	-
New Zealand	-	-	-	28.2	245.0	239.4	-
Solomon Islands	-	-	-	-	-	22.8	20.0
Total	0.0	0.0	0.0	28.2	848.4	486.8	53.0

Table 6. Fishing effort (millions of hooks) by the 'offshore, tropical waters' longline fleet category, 1998–2001

Year	Fishing effort
1998	61.317
1999	103.157
2000	97.184
2001	109.695

Table 7. Estimates of catches (tonnes) and coefficients of variation (%) for the 'offshore, tropical waters' longline fleet category

Species or Species Group	1998		1999		2000		2001		1998-2001	
	Catch	CV	Catch	CV	Catch	CV	Catch	CV	Catch	CV
Albacore	11,183	12.8	2,272	21.6	1,424	16.5	6,385	11.9	6,581	9.4
Bigeye tuna	7,132	6.3	18,921	6.7	19,479	6.8	16,043	10.8	14,819	4.7
Skipjack tuna	313	19.8	103	29.3	145	14.4	91	17.9	193	11.3
Yellowfin tuna	13,868	6.7	10,863	9.6	17,572	8.4	20,740	12.6	16,830	5.5
Black marlin	483	16.3	859	17.6	883	29.5	1,333	14.0	894	10.1
Blue marlin	2,721	9.6	1,682	17.3	2,778	12.7	1,372	12.4	2,339	6.4
Indo-Pacific sailfish	459	15.2	147	23.6	500	16.5	662	13.3	496	8.4
Shortbill spearfish	415	13.2	72	32.9	171	22.8	99	20.1	235	10.5
Striped marlin	231	22.6	548	23.9	935	14.7	296	24.1	486	10.0
Swordfish	1,090	15.3	1,266	14.4	2,027	9.2	951	16.2	1,367	6.9
Blue shark	7,432	9.1	9,716	8.5	5,820	9.2	3,372	13.7	6,655	5.1
Mako sharks	691	18.7	788	21.9	859	16.8	666	16.9	775	10.0
Oceanic whitetip shark	1,227	10.5	753	21.7	1,463	13.2	1,113	12.2	1,239	6.6
Silky shark	1,992	12.5	4,687	13.6	3,423	11.2	2,327	13.5	2,961	6.4
Other sharks and rays	805	11.6	525	12.1	613	11.0	553	20.4	684	6.8
Barracudas	130	12.3	77	21.7	173	11.8	372	13.0	204	8.0
Common dolphinfish	101	13.9	53	37.1	123	33.3	159	15.6	120	11.3
Escolars	22	30.7	59	41.9	178	25.2	63	29.7	79	17.3
Lancetfishes	31	15.6	27	36.1	164	16.3	66	33.4	74	12.2
Oilfish	108	16.5	30	34.4	191	16.6	154	56.1	134	18.2
Ocean sunfish	294	36.6	52	99.7	120	44.6	31	99.8	155	26.4
Opah	281	19.5	282	35.8	437	25.3	478	15.9	387	11.4
Pomfrets	14	24.3	58	33.0	47	17.4	30	25.9	34	12.0
Wahoo	488	8.8	154	20.6	171	14.7	335	12.7	338	6.7
Other fish	225	11.9	290	16.8	232	17.7	261	15.4	257	7.6
Total	51,736	5.4	54,284	4.5	59,927	4.4	57,951	8.1	58,336	3.4

Table 8. Estimates of catch rates (number of fish per 100 hooks and kilograms per 100 hooks) for the 'offshore, tropical waters' longline fleet category

Species or Species Group	1998		1999		2000		2001		1998-2001	
	n	kg	n	kg	n	kg	n	kg	n	kg
Albacore	1.0442	18.2374	0.1794	2.2024	0.1024	1.4656	0.3426	5.8210	0.4230	7.0885
Bigeye tuna	0.2980	11.6315	0.4352	18.3420	0.4871	20.0432	0.4844	14.6252	0.4308	15.9622
Skipjack tuna	0.0650	0.5102	0.0207	0.0997	0.0336	0.1487	0.0168	0.0830	0.0337	0.2078
Yellowfin tuna	0.7442	22.6165	0.4041	10.5305	0.6455	18.0813	0.7363	18.9067	0.6561	18.1287
Black marlin	0.0148	0.7870	0.0145	0.8324	0.0169	0.9086	0.0242	1.2153	0.0183	0.9628
Blue marlin	0.0821	4.4372	0.0231	1.6302	0.0503	2.8589	0.0229	1.2508	0.0446	2.5192
Indo-Pacific sailfish	0.0341	0.7486	0.0086	0.1422	0.0220	0.5144	0.0382	0.6033	0.0278	0.5346
Shortbill spearfish	0.0341	0.6762	0.0031	0.0701	0.0069	0.1762	0.0063	0.0901	0.0127	0.2527
Striped marlin	0.0069	0.3759	0.0086	0.5314	0.0164	0.9625	0.0057	0.2697	0.0093	0.5230
Swordfish	0.0440	1.7780	0.0266	1.2272	0.0514	2.0856	0.0244	0.8672	0.0367	1.4725
Blue shark	0.2179	12.1214	0.2026	9.4190	0.1246	5.9883	0.0563	3.0736	0.1395	7.1682
Mako sharks	0.0260	1.1275	0.0166	0.7640	0.0130	0.8836	0.0088	0.6075	0.0155	0.8347
Oceanic whitetip shark	0.0381	2.0018	0.0138	0.7295	0.0336	1.5052	0.0214	1.0145	0.0273	1.3348
Silky shark	0.0732	3.2486	0.0956	4.5431	0.1274	3.5224	0.0716	2.1213	0.0908	3.1896
Other sharks and rays	0.0477	1.3128	0.0331	0.5090	0.0431	0.6304	0.0216	0.5044	0.0356	0.7363
Barracudas	0.0336	0.2122	0.0100	0.0745	0.0315	0.1781	0.0613	0.3388	0.0377	0.2193
Common dolphinfish	0.0312	0.1655	0.0093	0.0514	0.0211	0.1267	0.0223	0.1450	0.0219	0.1288
Escolars	0.0030	0.0364	0.0038	0.0576	0.0144	0.1837	0.0031	0.0573	0.0061	0.0853
Lancetfishes	0.0240	0.0500	0.0138	0.0266	0.0841	0.1688	0.0223	0.0597	0.0374	0.0801
Oilfish	0.0141	0.1766	0.0048	0.0293	0.0148	0.1962	0.0107	0.1401	0.0116	0.1443
Ocean sunfish	0.0022	0.4788	0.0003	0.0504	0.0012	0.1230	0.0002	0.0279	0.0010	0.1672
Opah	0.0084	0.4575	0.0066	0.2733	0.0102	0.4498	0.0088	0.4361	0.0087	0.4163
Pomfrets	0.0049	0.0232	0.0055	0.0559	0.0146	0.0482	0.0063	0.0277	0.0080	0.0369
Wahoo	0.0754	0.7964	0.0159	0.1494	0.0169	0.1762	0.0303	0.3054	0.0353	0.3645
Other fish	0.0294	0.3670	0.0262	0.2816	0.0213	0.2383	0.0204	0.2376	0.0239	0.2772
Total	2.9968	84.3741	1.5819	52.6229	2.0040	61.6636	2.0671	52.8290	2.1932	62.8356

Table 9. Estimates of annual catches (tonnes) for the 'offshore, tropical waters' longline fleet category, by species group

Species Group	1998	1999	2000	2001	1998 - 2001
Tunas	32,495	32,159	38,620	43,259	38,423
Billfish	5,398	4,573	7,295	4,713	5,816
Sharks and Rays	12,148	16,469	12,177	8,031	12,314
Other Fish	1,695	1,083	1,836	1,948	1,782
Total	51,736	54,284	59,927	57,951	58,336

Table 10. Species composition (%) for the 'offshore, tropical waters' longline fleet category

Species Group	1998	1999	2000	2001	1998 - 2001
Tunas	62.8	59.2	64.4	74.6	65.9
Billfish	10.4	8.4	12.2	8.1	10.0
Sharks and Rays	23.5	30.3	20.3	13.9	21.1
Other Fish	3.3	2.0	3.1	3.4	3.1
Total	100.0	100.0	100.0	100.0	100.0

Table 11. Observed fishing effort (number of sets, number of hooks), observer coverage rate (%), factors of the coefficients of variation (see text), and the coefficients of variation (%) of estimates of the catch of all species combined, for the 'offshore, tropical waters' longline fleet category

Year	Observed Sets	Observed Hooks	Coverage Rate	Factor #1	Factor #2	Factor #3	Factor #4	Coef of Variation
1998	257	404,334	0.659	0.997	16.031	41.292	47.148	5.445
1999	177	289,777	0.281	0.999	13.304	15.378	25.898	4.457
2000	284	431,778	0.444	0.998	16.852	22.431	30.468	4.359
2001	266	523,979	0.478	0.998	16.310	53.878	40.718	8.094
1998-2001	984	1,649,868	0.444	0.998	31.369	39.084	36.773	3.381

Table 12. Catch per unit effort (number of fish per 100 hooks and kilograms per 100 hooks) and catch estimates (tonnes) based on commercial data and observer data, for bigeye caught by the 'offshore, tropical waters' longline fleet category

Year	Commercial Data			Observer Data			Difference (%)	
	CPUE - n	CPUE - kg	Catch	CPUE - n	CPUE - kg	Catch	n	kg
1998	0.35	13.79	8,457	0.30	11.63	7,132	-14.4	-15.7
1999	0.30	12.35	12,739	0.44	18.34	18,921	+47.0	+48.5
2000	0.28	10.98	10,672	0.49	20.04	19,479	+77.1	+82.5
2001	0.26	10.14	11,123	0.48	14.63	16,043	+85.6	+44.2

Table 13. Catch per unit effort (number of fish per 100 hooks and kilograms per 100 hooks) and catch estimates (tonnes) based on commercial data and observer data, for yellowfin caught by the 'offshore, tropical waters' longline fleet category

Year	Commercial Data			Observer Data			Difference (%)	
	CPUE - n	CPUE - kg	Catch	CPUE - n	CPUE - kg	Catch	n	kg
1998	0.46	13.08	8,020	0.74	22.62	13,868	+61.9	+72.9
1999	0.29	8.80	9,078	0.40	10.53	10,863	+40.9	+19.7
2000	0.36	10.39	10,102	0.65	18.08	17,572	+80.7	+73.9
2001	0.36	10.49	11,508	0.74	18.91	20,740	+102.3	+80.2