ANALYSIS OF LONGLINE CATCH PER VESSEL IN THE WESTERN AND CENTRAL PACIFIC OCEAN

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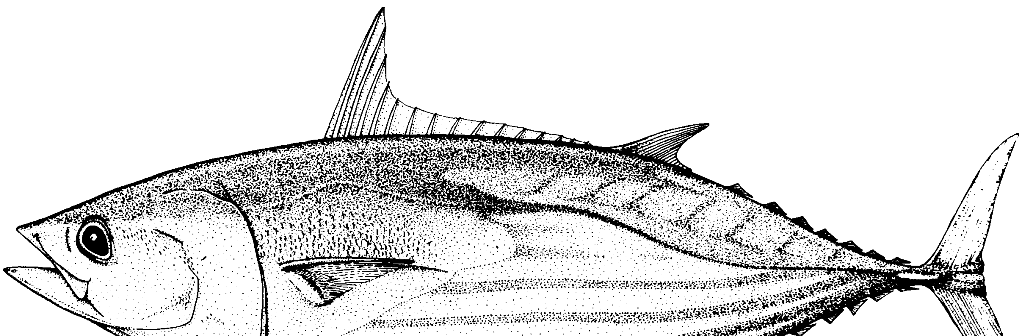
Oceanic Fisheries Programme
Internal Report No. 40



Oceanic Fisheries Programme
Secretariat of the Pacific Community
Noumea, New Caledonia

April 1999

INTRODUCTION

The SPC Oceanic Fisheries Programme (OFP) was contracted by the Forum Fisheries Agency (FFA) to study the relationship between longline catch per vessel for albacore (*Thunnus alalunga*), bigeye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*) in the central and western Pacific Ocean, and vessel attributes, such as gross registered tonnage (grt).

It is well known that larger longliners tend to stay at sea for longer periods and use more hooks per set, and therefore catch more fish per unit of time, than smaller boats. However, the nature of the relationship has not been examined. Factors in addition to vessel size that may also influence the catch per vessel include target behaviour, the time period and geographic area fished, and other aspects that may not be quantifiable, but consistent among vessels of a particular fishing nation.

This study attempts to identify those factors which may be related to longliner catch per vessel and to estimate the relative catch per vessel in terms of those factors.

ESTIMATION OF CATCH PER VESSEL

The principal source of data used to estimate catch per vessel has been catch and effort logsheet data held by the OFP. These data have been provided by SPC member countries and territories, which have compiled these data from domestic fleets or from vessels operating under bilateral access agreements with foreign fishing nations.

Coverage by logsheet data held at SPC of longliners fishing within the SPC Statistical Area (Figure 1) is incomplete. For example, coverage of catches during 1995 is only 57 percent. Coverage varies considerably among fleets and, within fleets, among years, ranging from zero to 100 percent (Table 2).

The incomplete coverage is due primarily to the lack of continuous coverage for those vessels that are covered, rather than to missing vessels. The average number of days covered per vessel per annum during 1978–1997 ranges from 29.3 days per vessel in 1979 to 92.9 days per vessel in 1995, and for the whole period is 66.6 days per vessel (Table 3).

Figure 2 shows the frequency of the number of days per vessel per annum, in 20 day intervals, covered by logsheet data. For just over half of all vessel-years, the number of days covered is less than 60. Individual vessels can be expected to fish for about 200 days per annum. In comparison, only 1.8 percent of all vessels-years in the OFP database are covered by more than 200 days.

Since the annual coverage of individual longliners by logsheet data held at SPC is poor, it has not been possible to estimate annual catches for individual vessels. Even for vessels for which coverage is relatively high, it is still not possible to determine whether gaps in the data represent periods that were not fished or periods for which logsheet data are missing.

Whereas the logsheet coverage rate for a particular vessel-year may be low, the coverage rates for one or more intervals of shorter duration during the year may be high. It is therefore reasonable to consider a shorter time period to estimate the catch per vessel. Given that catches for a period of one month may not contain enough information on the relationship with vessel attributes, while catches for a period of four to six months may still suffer from low logsheet coverage, a three-month period may be appropriate.

The problem concerning gaps in the logsheet data persists, however, regardless of the time period used. Some method of screening vessel-quarters for low logsheet coverage must be applied. Given that the duration between longline trips due to unloading is usually from a few days to less than two weeks, we would expect that gaps in the logsheet data of two weeks or longer may be due to missing data. While screening the logsheet data for gaps equal to or in excess of 14 days does not ensure that the estimates of the catch per vessel-quarter will always be accurate, it nevertheless is an objective method of dealing with the problem of coverage, which should not result in overly biased results.

The logsheet data held at SPC covered 38,503 vessel-quarters at the time of writing. After screening the vessel-quarters for gaps in the logsheet data of 14 days or greater, there were 3,577 vessel-quarters, or 9.3 percent, remaining.

The distributions, by fishing nation and grt class, of the number of vessels and the number of vessel-quarter replicates, covered by logsheet data after screening for 14 day gaps in the data, are presented in Tables 4 and 5 respectively. The number of vessels varies considerably among fishing nations, ranging from one vessel for the Marshall Islands and Samoa to 468 vessels for China (Table 4). The distribution of vessels among size classes also varies among fishing nations, with only the Japanese and Taiwanese fleets having vessels in all size classes (Table 4). The grt is unknown for 261 vessels, or 18.3 percent, out of a total of 1,426 vessels (Table 4). The distribution of the number of replicates is similar to the distribution of the number of vessels (Table 5).

The distribution of the average number of days fished per vessel-quarter is presented in Table 6. The number of days tends to increase with vessel size, which is consistent with the fact that larger vessels tend to take longer trips and spend a smaller proportion of time unloading than do smaller vessels. Departures from the trend are probably related to the small number of replicates for certain fishing nations and grt classes.

The distributions of the average catches of yellowfin, bigeye and albacore per vessel-quarter are presented in Tables 7–9 respectively. Catches tend to increase with vessel size; however, within a size class, catches vary considerably among fishing nations. Anomalous values are related to small numbers of replicates.

TARGETING

Targeting is perhaps best illustrated by examining the proportion of albacore in the catch. Table 10 presents the proportion of albacore in the average catch per vessel-quarter of yellowfin, bigeye and albacore per vessel-quarter, by fishing nation and grt class. The proportion ranges from less than 2 percent for American, Chinese, Federated States of Micronesia, small Japanese, small Solomon Islands and small Taiwanese vessels, to greater than 90 percent for large Taiwanese longliners. The vessels which catch less than 2 percent of albacore usually fish in tropical waters, where yellowfin and bigeye are the target species and where albacore are not abundant, while large Taiwanese vessels usually fish in the sub-tropical or temperate waters of Fiji, the Tasman Sea and the Sub-Tropical Convergence Zone, where albacore are abundant.

While the proportion of albacore is less than 2 percent or higher than 90 percent for certain groups of vessels, for other groups the proportion is intermediate, with relatively low values for Australian, Korean and Papua New Guinea longliners and relatively high values for Cook Islands, Fijian, French Polynesian, large Japanese, New Caledonian, New Zealand, Tongan and Vanuatu longliners.

An analysis of variance on the proportion of albacore in the catch per vessel-quarter of yellowfin, bigeye and albacore shows that it is strongly related to fishing nation (flag.id), vessel size (grt.class) and latitude (lat5), and less so to year (yy), quarter (qq) and longitude (lon5):

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
flag.id	17	132.8687	7.815806	662.9033	0
grt.class	7	42.8719	6.124562	519.4592	0
yy	18	4.8485	0.269359	22.8459	0
qq	3	1.9607	0.653581	55.4339	0
lat5	12	42.5358	3.544653	300.6424	0
lon5	25	2.9067	0.116267	9.8613	0
Residuals	3494	41.1952	0.011790		

A multiple regression with the same factors explained 83.6 percent of the variation in the proportion of albacore in the catch per vessel-quarter of yellowfin, bigeye and albacore, which further illustrates the strong relationship and suggests that targeting, as measured by the proportion of albacore, would be confounded with those factors in an analysis of the catch per vessel.

ANALYSIS OF CATCH PER VESSEL

Effects of individual variables

The effect of individual variables on the catch per vessel-quarter was determined using simple linear regressions. Table 11 presents the proportion of the variation in the catch per vessel-quarter, for albacore, bigeye and yellowfin, that was explained by individual variables.

The effect of individual variables depends on the species considered. The catch of yellowfin is moderately affected by fishing nation, the number of hooks per set and latitude. Targeting, as measured by the proportion of albacore in the catch, does not appear to have even a weak effect on the catch of yellowfin, when examined separately from other variables.

The catch of bigeye is strongly affected by fishing nation, latitude, longitude and grt class, and moderately affected by the number of hooks per set. The individual effect of the proportion of albacore is weak.

The catch of albacore is strongly affected by targeting as measured by the proportion of albacore in the catch, which is expected given the dependence between the two variables. The catch of albacore is also strongly affected by latitude and moderately affected by fishing nation, the number of hooks per set and grt class.

Multiple regressions on yellowfin catch per vessel-quarter

A stepwise multiple regression of the yellowfin catch per vessel-quarter was conducted. The following variables were tested in the analysis: fishing nation, grt class, number of hooks per set, year, quarter, latitude, longitude and the proportion of albacore in the catch. All variables were categorical, except the number of hooks per set and the proportion of albacore. The final model, which included all variables, explained 58.7 percent of the variation in the yellowfin catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
alb.pc	1	50527.6	50527.57	380.8350	0.000000e+00
hook	1	39855.4	39855.36	300.3967	0.000000e+00

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
flag.id	17	321482.0	18910.71	142.5332	0.000000e+00
lat5	12	136745.6	11395.47	85.8896	0.000000e+00
lon5	25	73514.4	2940.57	22.1636	0.000000e+00
grt.class	7	14537.9	2076.85	15.6536	0.000000e+00
qq	3	5797.1	1932.35	14.5645	1.995814e-09
yy	18	17079.5	948.86	7.1517	0.000000e+00
Residuals	3492	463303.7	132.68		

A second regression was conducted, with the proportion of albacore excluded from the analysis. The model explained 55.0 percent of the variation in the yellowfin catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
flag.id	17	321482.0	18910.71	130.7294	0.000000e+00
hook	1	13864.0	13864.03	95.8418	0.000000e+00
grt.class	7	79308.3	11329.76	78.3225	0.000000e+00
lat5	12	111621.1	9301.76	64.3029	0.000000e+00
lon5	25	59300.7	2372.03	16.3978	0.000000e+00
yy	18	28654.7	1591.93	11.0050	0.000000e+00
qq	3	3331.3	1110.43	7.6764	4.122589e-05
Residuals	3493	505281.0	144.66		

A third regression was conducted to examine the effect of fishing nation and vessel attributes in isolation from other variables. The model, which consisted of fishing nation, grt class and the number of hooks per set, explained 36.9 percent of the variation in the yellowfin catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
flag.id	17	321482.0	18910.71	94.78915	0.000000e+00
hook	1	13618.1	13618.13	68.26031	2.220446e-16
grt.class	7	79308.3	11329.76	56.78996	0.000000e+00
Residuals	3551	708434.7	199.50		

A fourth regression was conducted with only vessel attributes, i.e. grt class and the number of hooks per set. The model explained 28.0 percent of the variation in the yellowfin catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
hook	1	151072.6	151072.6	666.8657	0
grt.class	7	163471.2	23353.0	103.0851	0
Residuals	3568	808299.3	226.5		

The results from the fourth multiple regression indicates that vessel attributes alone explain only a moderate level of variation in the yellowfin catch per vessel-quarter. The first three regressions indicate that the amount of variation explained increases considerably with the addition of other variables. This suggests that it may not be appropriate to characterise the catch per vessel on the basis of vessel attributes alone.

The first regression indicates that targeting, as measured by the proportion of albacore, is significant when examined with other variables, in contrast to when it is examined as a separate variable (see above). However, the percentage of the variance explained decreases by only a small amount when the proportion of albacore is excluded in the second regression, which is consistent with the observation (see above) that the proportion of albacore is itself strongly related to other variables in the analysis. On the other hand, it may also be that the proportion of albacore is not an adequate measure of targeting for yellowfin or that targeting is of lesser importance for yellowfin, which is caught in quantity by almost all fleets, than for the other species.

Multiple regressions on bigeye catch per vessel-quarter

A stepwise multiple regression of the bigeye catch per vessel-quarter was conducted with the same variables as for yellowfin. The final model, which included all variables except grt class and quarter, explained 75.8 percent of the variation in the bigeye catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
flag.id	17	585502.3	34441.31	568.5764	0.00000000
alb.pc	1	4988.0	4987.96	82.3440	0.00000000
lat5	12	27618.6	2301.55	37.9952	0.00000000
yy	18	22540.0	1252.22	20.6724	0.00000000
hook	1	893.0	892.97	14.7417	0.00012547
lon5	25	21911.5	876.46	14.4691	0.00000000
Residuals	3502	212132.4	60.57		

A second regression was conducted, with the proportion of albacore excluded from the analysis. The model explained 75.1 percent of the variation in the yellowfin catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
flag.id	17	585502.3	34441.31	553.8259	0.00000000
yy	18	30138.2	1674.35	26.9239	0.00000000
lat5	12	20020.3	1668.36	26.8277	0.00000000
lon5	25	21911.5	876.46	14.0937	0.00000000
hook	1	168.8	168.82	2.7148	0.09951418
Residuals	3503	217844.5	62.19		

A third regression was conducted to examine the effect of fishing nation and vessel attributes in isolation from other variables. The model explained 67.9 percent of the variation in the bigeye catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
flag.id	17	585502.3	34441.31	435.5399	0.0000000
grt.class	7	9074.5	1296.35	16.3935	0.0000000
hook	1	205.5	205.47	2.5983	0.1070652
Residuals	3551	280803.4	79.08		

A fourth regression was conducted with only vessel attributes, i.e. grt class and the number of hooks per set. The model explained 42.6 percent of the variation in the bigeye catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
grt.class	7	339917.7	48559.67	344.7070	0
hook	1	33035.5	33035.47	234.5065	0
Residuals	3568	502632.4	140.87		

The results from the fourth multiple regression indicates that vessel attributes alone explain a moderate level of variation in the bigeye catch per vessel-quarter. The level of variation explained by vessel attributes alone is greater than for yellowfin and albacore (see below); however, the first two regressions show that in the presence of other factors, grt class is unimportant, while the number of hooks per set is significant in the first regression, but insignificant in the second. The amount of variation explained increases considerably with the addition of other variables, particularly fishing nation. The first two regressions indicate that, as for yellowfin, the percentage of the variance explained decreases by only a small amount when the proportion of albacore is excluded.

Multiple regressions on albacore catch per vessel-quarter

A stepwise multiple regression of the albacore catch per vessel-quarter was conducted with the same variables as for yellowfin and bigeye. The final model, which included all variables except year, quarter and longitude, explained 79.9 percent of the variation in the albacore catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
alb.pc	1	690446.8	690446.8	10412.24	0
hook	1	31173.0	31173.0	470.10	0
flag.id	17	149925.5	8819.1	133.00	0
lat5	12	52561.6	4380.1	66.05	0
grt.class	7	7005.1	1000.7	15.09	0
Residuals	3538	234608.6	66.3		

A second regression was conducted, with the proportion of albacore excluded from the analysis. The model explained 69.8 percent of the variation in the albacore catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
hook	1	87414.9	87414.91	878.5806	0
lat5	12	387805.9	32317.16	324.8099	0
flag.id	17	319177.4	18775.14	188.7032	0
grt.class	7	19207.4	2743.92	27.5783	0
Residuals	3539	352115.0	99.50		

A third regression was conducted to examine the effect of fishing nation and vessel attributes in isolation from other variables. The model explained 61.3 percent of the variation in the albacore catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
hook	1	163463.0	163463.0	1285.407	0
grt.class	7	231505.6	33072.2	260.067	0
flag.id	17	319177.4	18775.1	147.640	0
Residuals	3551	451574.6	127.2		

A fourth regression was conducted with only vessel attributes, i.e. grt class and the number of hooks per set. The model explained 33.5 percent of the variation in the albacore catch per vessel-quarter. F-statistics are given below:

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
grt.class	7	232633.1	33233.3	153.0648	0
hook	1	158406.2	158406.2	729.5819	0
Residuals	3568	774681.2	217.1		

The results from the fourth multiple regression indicates that vessel attributes alone explain only a moderate level of variation in the albacore catch per vessel-quarter. The first three regressions indicate that the amount of variation explained increases considerably with the addition of other variables, particularly fishing nation. The first two regressions indicate that the percentage of the variance explained decreases by 10.1 percent when the proportion of albacore is excluded. This amount is greater than for yellowfin and bigeye, which is to be expected given the dependence between the proportion of albacore and the albacore catch per vessel-quarter.

Average catch per vessel-quarter

We have seen that the catch per vessel-quarter for yellowfin, bigeye and albacore is strongly related to several factors other than vessel attributes, i.e. fishing nation, latitude, longitude, year and quarter, which suggests that it may not be appropriate to characterise the fishing power of vessels solely on the basis of vessel attributes.

We have also seen that targeting, as measured by the proportion of albacore in the catch, is continuous across fleets, rather than discrete. This would suggest that it may not be appropriate to stratify fleets into discrete classes based on targeting behaviour.

Nevertheless, it is of interest to examine the average catch per vessel-quarter in a manner that takes vessel attributes and targeting into account in order to see if any patterns are evident. To this end, the average catch per vessel-quarter was summarised by grt class for (a) all areas combined, and separately for (b) low latitudes, i.e. from 10°N to 10°S, and (c) high latitudes, i.e. north of 10°N and south of 10°S. Vessels fishing from 10°N to 10°S generally catch a negligible amount of albacore, while those fishing beyond this band – which includes the waters off the south-east coast of Australia, the waters of Fiji, French Polynesia, New Caledonia and Tonga, and international waters adjacent to those countries and territories – catch a significant amount of albacore, although at varying levels.

Tables 12–14 present the mean, standard error and standard deviation of the catch per vessel-quarter by grt class and area fished, for yellowfin, bigeye and albacore respectively.

For yellowfin, there appears to be a large difference in the catch per vessel-quarter between vessels smaller than 200 grt and vessels larger than 200 grt. Vessels smaller than 200 grt have a mean yellowfin catch per vessel-quarter of 9.9 t, while those larger than 200 grt have a mean of 25.2 t. Hence, it would appear that vessels larger than 200 grt catch about 2.6 times as much yellowfin as vessels smaller than 200 grt. On the other hand, the yellowfin catch per vessel-quarter does not appear to increase consistently among grt classes either for vessels smaller than 200 grt or for vessels larger than 200 grt.

The standard errors of the mean catch per vessel-quarter for yellowfin, bigeye and albacore are small, due to the relatively large number of vessel-quarter replicates. However, it should be noted that the standard deviations of the catch per vessel-quarter are large, i.e. about the same size as the mean, which implies a wide range in the distribution of the catch for individual vessel-quarters. Hence, for yellowfin, while the catch per vessel-quarter for vessels larger than 200 grt is, on average, much greater than for vessels smaller than 200 grt, the relationship is not precise. Smaller vessels often catch relatively large amounts of yellowfin, while large vessels often catch small amounts.

While the yellowfin catch per vessel-quarter is strongly related to vessel size, it does not appear to be related to area. The means of the yellowfin catch per vessel-quarter between 10°N and 10°S are about the same as for areas outside this latitudinal band.

A similar difference in the bigeye catch per vessel-quarter is evident between vessels smaller than 200 grt and vessels larger than 200 grt. However, the bigeye catch per vessel-quarter also depends on area, such that catches are greater and the relationship among grt classes is stronger between 10°N and 10°S than outside that area. The mean bigeye catch per vessel-quarter between 10°N and 10°S is 9.5 t for vessels smaller than 200 grt, compared to 42.4 t for vessels larger than 200 grt. Beyond that area, the means are 6.5 t for vessels smaller than 200 grt and 11.3 t for vessels larger than 200 grt.

The difference in the relative magnitude of the mean catch per vessel-quarter is 4.5 between 10°N and 10°S and 1.7 beyond that area.

For albacore, the difference among areas is much greater than the differences among grt classes. The mean albacore catch per vessel-quarter between 10°N and 10°S is 0.8 t, compared to 30.7 t beyond that area. Within 10°N and 10°S, the relative magnitude of catches by vessels larger and smaller than 200 grt is high; however, catches for both groups are small. Beyond that area, there appears to be a stronger difference between vessels smaller and larger than 100 grt than between vessels smaller and larger than 200 grt.

CONCLUSION

An analysis of longline catch per vessel is limited by the low coverage of logsheet data, which does not permit estimation of the annual catch per vessel. However, reducing the time period from year to quarter and excluding logsheet data with greater than 14-day gaps results in replicates of catch per vessel-quarter that appear to contain useful information.

The catch per vessel-quarter for each of the three target species (yellowfin, bigeye and albacore) varies considerably by grt class. However, the catch per vessel is also related to other factors, including fishing nation, time period, and latitude and longitude fished, which suggests that it may not be appropriate to characterise the catch per vessel by vessel attributes alone.

While targeting should be taken into account, it has been shown that targeting varies continuously among fleets, rather than discretely, which implies that stratifying the fleets according to their targeting behaviour may not be appropriate. Targeting, as measured by the proportion of albacore in the catch, was found to be strongly related to vessel flag, grt class and latitude.

Patterns in the catch per vessel-quarter related to grt class and area fished are evident, although the patterns vary among species. For yellowfin, there is a strong relationship between catch per vessel-quarter and vessel size, i.e. vessels smaller or larger than 200 grt. For bigeye, there are strong relationships between catch per vessel-quarter and both area fished and vessel size, i.e. smaller or larger than 200 grt. For albacore, the relationship between the catch per vessel-quarter and area fished is much stronger than the relationship between the catch per vessel-quarter and vessel size.

In spite of the problem in estimating the annual catch per vessel, the relative magnitudes of the catch per vessel-quarter for the categories of vessel size and area fished shown herein – or for other categories of vessel size, area fished or perhaps other factors – could possibly be used in a system to allocate the total allowable catch based on the catch per vessel. However, the development of such a system is seriously complicated by the fact that the fishery is multispecies, while the catch per vessel varies among categories in a manner that is particular to each of the species. A more useful approach may be to investigate the effects of controls on vessel numbers using a simulation model that incorporates both fish population dynamics and fishing fleet dynamics. Such a model is currently under development by the SPC Oceanic Fisheries Programme.

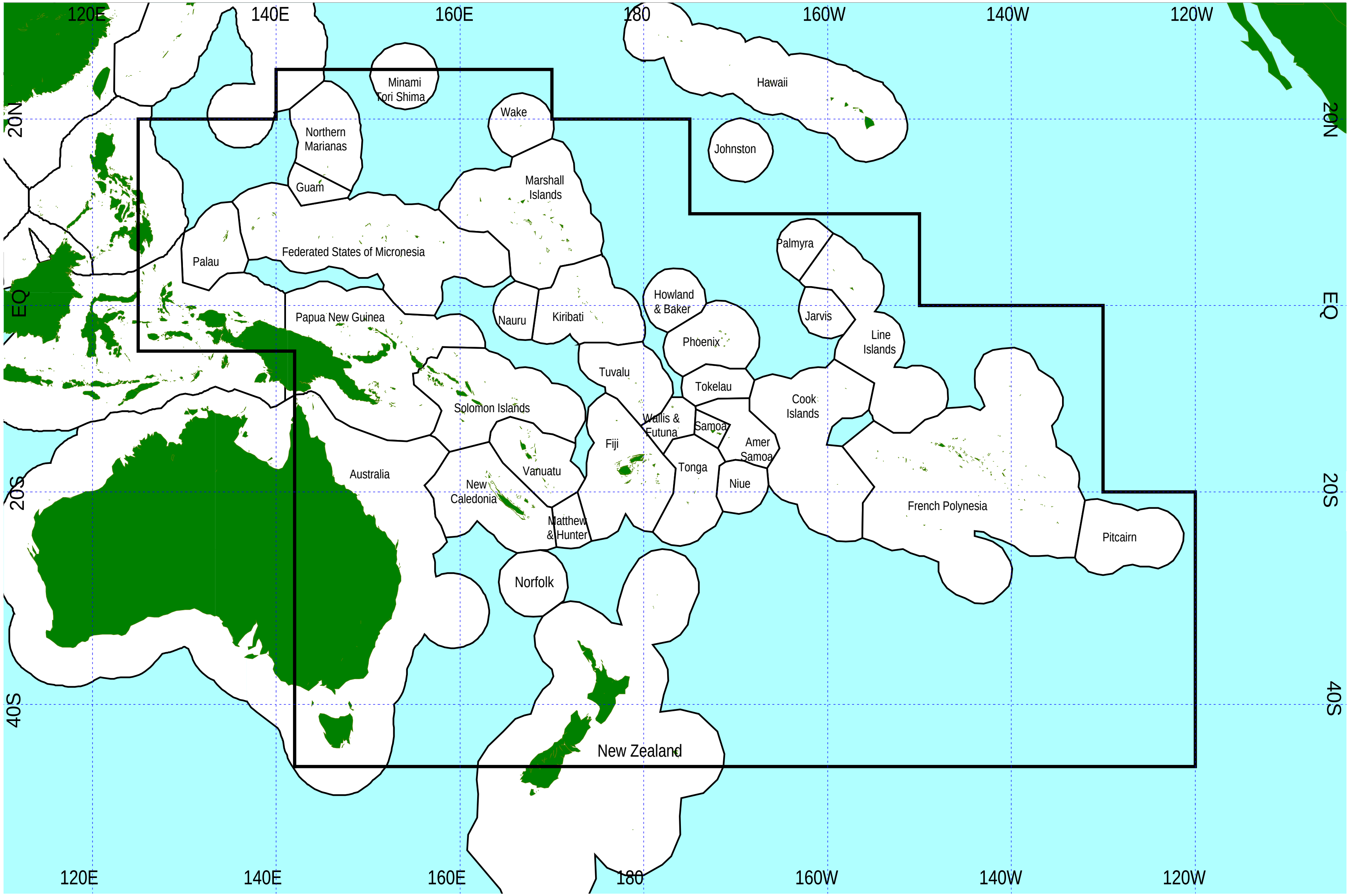


Figure 1. SPC Statistical Area

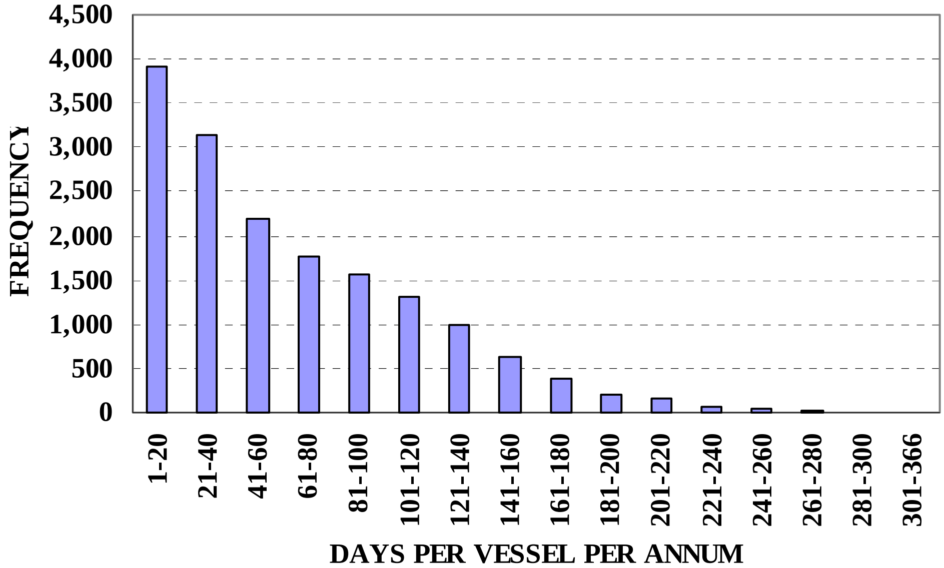


Figure 2. Frequency of the number of days per vessel per annum covered by longline logsheet data held at SPC

Table 1. Coverage (percent) of catches (tonnes) within the SPC Statistical Area by logsheet data held at SPC. Statistics for 1996 and 1997 are preliminary.

GEAR TYPE	1990	1991	1992	1993	1994	1995	*1996**	*1997**
DRIFTNET								
VESSELS	0	0	-	-	-	-	-	-
DAYS	0	0	-	-	-	-	-	-
LOGSHEET CATCH	0	0	-	-	-	-	-	-
TOTAL CATCH	7,426	821	0	0	0	0	*0*	*0*
COVERAGE	0	0	-	-	-	-	-	-
LONGLINE								
VESSELS	936	788	939	1,126	1,263	1,254	*1,030*	*693*
DAYS	49,997	45,336	55,014	81,107	101,997	112,512	*71,878*	*39,037*
LOGSHEET CATCH	43,197	32,809	42,405	42,145	63,589	64,452	*42,692*	*24,162*
TOTAL CATCH	115,057	91,686	105,914	115,794	136,683	113,518	*108,102*	...
COVERAGE	38	36	40	36	47	57	*39*	...
POLE-AND-LINE								
VESSELS	113	111	94	87	89	106	*116*	*56*
DAYS	10,151	11,250	9,508	9,090	9,829	11,387	*8,554*	*1,282*
LOGSHEET CATCH	42,876	68,285	38,810	35,634	40,133	65,013	*34,404*	*11,592*
TOTAL CATCH	82,451	97,833	73,648	64,641	68,949	82,289	*67,300*	...
COVERAGE	52	70	53	55	58	79	*51*	...
PURSE SEINE								
VESSELS	168	187	190	194	192	188	*183*	*173*
DAYS	22,738	23,478	25,679	31,573	29,862	28,297	*31,980*	*22,827*
LOGSHEET CATCH	366,638	432,051	479,250	578,221	694,149	628,233	*646,811*	*462,261*
TOTAL CATCH	664,918	858,651	855,996	718,322	822,579	757,642	*690,178*	...
COVERAGE	55	50	56	80	84	83	*94*	...
TROLL								
VESSELS	2	1	28	52	59	48	*0*	*0*
DAYS	8	13	382	1,120	1,060	537	*0*	*0*
LOGSHEET CATCH	2	0	24	51	95	9	*0*	*0*
TOTAL CATCH	6,750	8,330	6,944	4,929	5,003	8,503	*8,119*	...
COVERAGE	0	0	0	1	2	0	*0*	...
TOTAL								
VESSELS	1,219	1,087	1,251	1,459	1,603	1,596	*1,048*	*922*
DAYS	82,894	80,077	90,583	122,890	142,748	152,733	*82,496*	*63,146*
LOGSHEET CATCH	452,714	533,145	560,489	656,051	797,965	757,707	*450,536*	*498,016*
TOTAL CATCH	876,602	1,057,321	1,042,502	903,686	1,033,214	961,952	*873,699*	...
COVERAGE	52	50	54	73	77	79	*52*	...

Table 2. Coverage (percent) of catches (tonnes) within the SPC Statistical Area by logsheet data held at SPC, by fishing nation. Statistics for 1996 are preliminary. Dashes indicate no coverage. Spaces indicate no fishing. Values equal to 100 indicate that total catch estimates are based on logsheet data. Values greater than 100 are due to rounding errors or total catch estimates based on national statistics. Codes: AS = American Samoa, AU = Australia, CK = Cook islands, CN = China, FM = Federated States of Micronesia, FJ = Fiji, PF = French Polynesia, JP = Japan, KR = Korea, MH = Marshall Islands

YEAR	AS	AU	CK	CN	FM	FJ	PF	JP	KR	MH
1953								-		
1954								-		
1955								-		
1956								-		
1957								-		
1958								-	-	
1959								-	-	
1960								-	-	
1961								-	-	
1962								-	-	
1963								-	-	
1964								-	-	
1965								-	-	
1966								-	-	
1967								-	-	
1968								-	-	
1969								-	-	
1970								-	-	
1971								-	-	
1972								-	-	
1973								-	-	
1974								-	-	
1975								-	-	
1976								-	-	
1977								-	-	
1978								0.3	-	
1979								11.5	1.0	
1980								17.7	0.8	
1981								23.1	6.7	
1982								22.5	6.7	
1983								22.4	12.0	
1984								24.4	12.8	
1985		100.0						25.5	29.9	
1986		100.0						19.2	31.5	
1987		100.0						18.2	27.3	
1988		100.0		100.0				21.8	29.4	
1989		100.0		100.0			-	27.1	32.5	
1990		100.0		100.0		89.0	-	23.0	37.1	
1991		100.0		82.1	77.8	68.4	-	21.3	36.8	
1992		100.0		99.3	107.2	82.9	35.6	24.9	27.1	100.0
1993		100.0		96.4	88.8	54.3	5.1	13.5	58.0	50.7
1994		100.0	71.1	91.2	71.3	78.0	37.4	17.9	65.9	-
1995	-	100.0	75.3	88.8	68.6	79.6	53.0	25.4	59.8	45.2
1996	-	100.0	64.0	82.9	62.0	15.6	38.4	37.3	34.8	

Table 2 (continued) Codes: NC = New Caledonia, NZ = New Zealand, PG = Papua New Guinea, SB = Solomon Islands, TW–DW = Taiwan, distant-water, TW–OS = Taiwan, offshore, TO = Tonga, US = United States of America, VU = Vanuatu

YEAR	NC	NZ	PG	SB	TW-DW	TW-OS	TO	US	VU
1953									
1954									
1955									
1956									
1957									
1958									
1959									
1960									
1961									
1962									
1963									
1964					-				
1965					-				
1966					-				
1967					-				
1968					-				
1969					-				
1970					-				
1971					-				
1972					-				
1973				-	-				
1974				-	-				
1975				-	-				
1976				-	-				
1977				-	-				
1978				-	-				
1979				-	-				
1980				-	0.2				
1981				-	2.4				
1982				83.7	12.0		55.1		
1983	95.2			100.2	8.1		56.7		
1984	100.0			100.3	28.8		45.9		
1985	100.0			100.5	22.3		30.9		
1986	100.0			-	-		80.9		
1987	92.3			-	1.9	100.0	90.3		
1988	65.9			-	16.6	100.0	87.6		
1989	75.1	-	-	-	5.0	100.0	88.9		
1990	58.0	-	-	-	1.6	16.4	100.0		
1991	40.4	8.1	-	-	5.9	29.0	100.0	4.0	
1992	46.6	11.9	35.6	-	10.0	56.3	99.6	91.1	
1993	69.5	100.4	5.1	-	46.2	58.6	19.1	35.0	
1994	20.0	100.2	37.4	-	20.0	91.3	92.2	51.7	
1995	42.0	100.2	53.0	61.9	19.8	86.4	-	49.7	100.0
1996	55.3	100.0	38.4	28.6	18.2	90.6	3.5	67.4	87.1

Table 3. Days fished, number of longline vessels and average days per vessel covered by logsheet data held at SPC

YEAR	DAYS	VESSELS	AVG DAYS
1979	18,537	633	29.3
1980	45,799	979	46.8
1981	55,690	895	62.2
1982	52,489	661	79.4
1983	36,541	534	68.4
1984	46,461	604	76.9
1985	47,113	662	71.2
1986	28,453	451	63.1
1987	35,281	627	56.3
1988	46,464	816	56.9
1989	51,716	820	63.1
1990	51,043	916	55.7
1991	47,209	761	62.0
1992	55,874	923	60.5
1993	82,318	1,116	73.8
1994	103,336	1,248	82.8
1995	114,221	1,229	92.9
1996	75,062	1,002	74.9
1997	49,396	772	64.0
TOTAL	1,043,003	15,649	66.6

Table 4. Number of vessels, by fishing nation and grt class, after screening vessel-quarter replicates for 14-day gaps in logsheet data

FLAG	UNKNOWN	1-24	25-59	60-99	100-199	200-299	300-399	400+	TOTAL
AU	102								102
CK					2				2
CN	16	9	32	212	199				468
FJ	1	1	10	7	3	1	1		24
FM	1	1	4	1					7
JP	28	90	7	36	70	80	55	1	367
KR	24			2		12	60	72	170
MH	1								1
NC	12				1				13
NZ	28								28
PF	23	1	1		2				27
PG	6		1						7
SB	1	1	5	1	1			1	10
TO	1	1			1				3
TW	17	2	72	39	40	16	3	1	190
US			3			1			4
VU								2	2
WS		1							1
TOTAL	261	107	135	298	319	110	119	77	1,426

Table 5. Number of vessel-quarter replicates, by fishing nation and grt class, after screening replicates for 14-day gaps in logsheet data

FLAG	UNKNOWN	1-24	25-59	60-99	100-199	200-299	300-399	400+	TOTAL
AU	312								312
CK					6				6
CN	22	23	99	607	450				1,201
FJ	1	1	40	27	9	16	16		110
FM	1	1	8	1					11
JP	32	264	13	47	156	216	124	2	854
KR	84			2		25	143	242	496
MH	1								1
NC	35				2				37
NZ	52								52
PF	79	1	5		2				87
PG	15		1						16
SB	1	1	7	1	1			1	12
TO	1	1			6				8
TW	23	2	140	55	89	41	7	1	358
US			10			1			11
VU								4	4
WS		1							1
TOTAL	659	295	323	740	721	299	290	250	3,577

Table 6. Average number of days fished per vessel-quarter, by fishing nation and grt class, after screening replicates for 14-day gaps in logsheet data

FLAG	UNKNOWN	1-24	25-59	60-99	100-199	200-299	300-399	400+
AU	32.1							
CK					61.7			
CN	52.7	50.8	55.7	55.8	50.4			
FJ	46.0	46.0	56.9	55.5	60.4	65.7	65.8	
FM	35.0	53.0	38.3	48.0				
JP	70.0	51.8	50.7	57.1	65.3	70.6	69.7	51.0
KR	75.5			42.0		70.7	74.1	75.9
MH	46.0							
NC	54.6				48.5			
NZ	36.1							
PF	40.0	44.0	38.2		37.5			
PG	52.7		58.0					
SB	68.0	51.0	58.6	65.0	72.0			74.0
TO	42.0	34.0			62.7			
TW	55.2	38.5	48.3	50.2	72.0	73.2	82.0	64.0
US			57.5			50.0		
VU								71.0
WS		33.0						
AVERAGE	50.4	44.7	51.4	53.4	58.9	66.0	72.9	67.2

Table 7. Average yellowfin catch (t) per vessel-quarter, by fishing nation and grt class, after screening replicates for 14-day gaps in logsheet data

FLAG	UNKNOWN	1-24	25-59	60-99	100-199	200-299	300-399	400+
AU	11.1							
CK					3.4			
CN	4.6	4.6	5.3	4.9	6.4			
FJ	5.8	4.4	5.6	9.9	5.4	8.5	8.7	
FM	9.8	3.8	5.0	9.6				
JP	27.7	12.4	18.5	27.3	38.9	29.4	39.6	11.7
KR	21.7			8.1		23.0	20.5	23.3
MH	4.8							
NC	22.0				23.0			
NZ	1.6							
PF	2.5	0.2	2.8		3.2			
PG	18.5		12.2					
SB	81.9	24.1	21.9	24.2	29.1			66.0
TO	1.8	0.6			10.0			
TW	5.4	3.1	7.8	10.2	4.4	3.3	6.0	3.6
US			10.7			9.1		
VU								40.0
WS		1.8						
AVERAGE	15.7	6.1	10.0	13.5	13.8	14.7	18.7	28.9

Table 8. Average bigeye catch (t) per vessel-quarter, by fishing nation and grt class, after screening replicates for 14-day gaps in logsheet data

FLAG	UNKNOWN	1-24	25-59	60-99	100-199	200-299	300-399	400+
AU	2.0							
CK					2.5			
CN	4.3	4.6	6.6	6.2	6.9			
FJ	2.4	1.9	4.6	6.4	5.7	6.6	4.5	
FM	2.1	11.6	2.2	7.8				
JP	7.2	17.6	21.0	17.6	15.8	12.3	11.1	2.6
KR	44.7			29.1		34.3	41.4	44.2
MH	6.3							
NC	3.7				2.9			
NZ	1.3							
PF	1.6	0.4	1.8		7.7			
PG	2.4		0.4					
SB	18.5	5.6	27.1	29.9	11.2			18.1
TO	0.7	1.8			3.3			
TW	4.5	9.0	9.8	10.5	1.5	0.8	3.5	1.9
US			6.2			5.6		
VU								14.4
WS		1.4						
AVERAGE	7.3	6.0	8.9	15.4	6.4	11.9	15.1	16.2

Table 9. Average albacore catch (t) per vessel-quarter, by fishing nation and grt class, after screening replicates for 14-day gaps in logsheet data

FLAG	UNKNOWN	1-24	25-59	60-99	100-199	200-299	300-399	400+
AU	2.1							
CK					5.1			
CN								
FJ	5.4	17.3	20.5	22.7	33.9	36.5	46.5	
FM								
JP	12.8	0.2	0.1	3.4	13.5	22.8	29.4	17.8
KR	4.0					9.0	3.7	4.5
MH								
NC	38.2				35.9			
NZ	9.2							
PF	12.7	13.4	17.0		36.2			
PG	5.4		0.7					
SB	71.7		0.7		2.0			47.7
TO	27.5	6.5			44.9			
TW	23.5		0.2	0.1	53.3	69.7	101.0	32.2
US						0.1		
VU								58.2
WS		7.1						
AVERAGE	19.3	8.9	6.5	8.7	28.1	27.6	45.2	32.1

Table 10. Percentage of albacore in the average catch of yellowfin, bigeye and albacore per vessel-quarter, by fishing nation and grt class, after screening replicates for 14-day gaps in logsheet data

FLAG	UNKNOWN	1-24	25-59	60-99	100-199	200-299	300-399	400+
AU	13.7							
CK					46.4			
CN	0.0	0.0	0.0	0.2	0.0			
FJ	39.5	73.3	66.8	58.2	75.3	70.8	77.9	
FM	0.0	0.0	0.0	0.0				
JP	26.9	0.8	0.3	7.1	19.8	35.3	36.7	55.6
KR	5.7			0.0		13.6	5.6	6.2
MH	0.0							
NC	59.8				58.2			
NZ	76.0							
PF	75.4	96.1	78.7		76.9			
PG	20.5		5.1					
SB	41.6	0.0	1.4	0.0	4.7			36.2
TO	91.7	73.1			77.0			
TW	70.3	0.0	1.2	0.6	90.1	94.4	91.4	85.3
US			0.0			0.7		
VU								51.7
WS		69.2						
AVERAGE	37.2	34.7	17.1	9.4	49.8	43.0	52.9	47.0

Table 11. Percentage of variation in the catch of yellowfin (YFT), bigeye (BET) and albacore (ALB) per vessel-quarter explained by individual variables

VARIABLE	YFT	BET	ALB
FLAG	28.6	66.9	27.4
GRT CLASS	14.6	38.8	20.0
HOOKS PER SET	26.3	20.6	23.8
LONGITUDE	8.9	47.0	14.1
LATITUDE	25.0	47.0	42.7
YEAR	14.7	5.1	8.1
QUARTER	0.7	0.1	0.4
PROP OF ALB	0.1	6.6	59.2

Table 12. Number of vessel-quarter replicates (N), mean catch of yellowfin per vessel-quarter (t), standard error of the mean catch of yellowfin per vessel-quarter (t), and the standard deviation of the catch of yellowfin per vessel-quarter (t), by grt class, for (a) all vessel-quarters, (b) vessel-quarters between 10°N and 10°S, and (c) vessel-quarters north of 10°N and south of 10°S

(a) ALL VESSEL-QUARTERS

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	295	11.58	0.44	7.57
25-59	323	7.46	0.34	6.11
60-99	740	6.93	0.26	7.05
100-199	721	13.21	0.72	19.41
200-299	299	24.08	1.26	21.76
300-399	290	27.70	1.64	27.94
400+	250	23.57	1.05	16.65

(b) BETWEEN 10N AND 10S

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	269	11.73	0.47	7.63
25-59	267	7.70	0.37	6.08
60-99	705	6.64	0.25	6.74
100-199	521	11.55	0.74	16.78
200-299	31	30.86	4.55	25.35
300-399	141	20.80	1.28	15.22
400+	225	23.37	1.09	16.40

(c) NORTH OF 10N AND SOUTH OF 10S

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	26	10.03	1.31	6.70
25-59	56	6.31	0.82	6.15
60-99	35	12.78	1.70	10.06
100-199	200	17.55	1.73	24.46
200-299	268	23.30	1.29	21.16
300-399	149	34.22	2.85	34.83
400+	25	25.41	3.73	18.65

Table 13. Number of vessel-quarter replicates (N), mean catch of bigeye per vessel-quarter (t), standard error of the mean catch of bigeye per vessel-quarter (t), and the standard deviation of the catch of bigeye per vessel-quarter (t), by grt class, for (a) all vessel-quarters, (b) vessel-quarters between 10°N and 10°S, and (c) vessel-quarters north of 10°N and south of 10°S

(a) ALL VESSEL-QUARTERS

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	295	16.25	0.41	6.99
25-59	323	8.57	0.35	6.36
60-99	740	7.38	0.19	5.03
100-199	721	8.05	0.31	8.29
200-299	299	12.26	0.73	12.55
300-399	290	25.49	1.23	20.92
400+	250	43.12	1.18	18.62

(b) BETWEEN 10N AND 10S

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	269	15.98	0.40	6.49
25-59	267	9.29	0.38	6.27
60-99	705	7.43	0.19	5.09
100-199	521	9.10	0.38	8.69
200-299	31	33.18	3.31	18.43
300-399	141	41.35	1.43	16.98
400+	225	44.35	1.19	17.91

(c) NORTH OF 10N AND SOUTH OF 10S

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	26	19.05	2.05	10.43
25-59	56	5.12	0.75	5.61
60-99	35	6.54	0.61	3.59
100-199	200	5.32	0.45	6.38
200-299	268	9.84	0.55	8.95
300-399	149	10.49	0.88	10.77
400+	25	32.03	4.22	21.11

Table 14. Number of vessel-quarter replicates (N), mean catch of albacore per vessel-quarter (t), standard error of the mean catch of albacore per vessel-quarter (t), and the standard deviation of the catch of albacore per vessel-quarter (t), by grt class, for (a) all vessel-quarters, (b) vessel-quarters between 10°N and 10°S, and (c) vessel-quarters north of 10°N and south of 10°S

(a) ALL VESSEL-QUARTERS

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	295	0.36	0.10	1.75
25-59	323	2.91	0.50	8.89
60-99	740	1.07	0.20	5.50
100-199	721	10.54	0.75	20.16
200-299	299	28.73	1.50	25.98
300-399	290	19.36	1.61	27.40
400+	250	5.72	0.73	11.60

(b) BETWEEN 10N AND 10S

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	269	0.16	0.06	0.92
25-59	267	0.05	0.04	0.66
60-99	705	0.09	0.03	0.84
100-199	521	0.38	0.08	1.74
200-299	31	7.12	2.53	14.10
300-399	141	3.55	0.38	4.50
400+	225	3.39	0.27	4.03

(c) NORTH OF 10N AND SOUTH OF 10S

GRT	N	MEAN	STANDARD ERROR	STANDARD DEVIATION
1-24	26	2.38	0.91	4.62
25-59	56	16.56	2.02	15.12
60-99	35	20.91	2.47	14.59
100-199	200	37.00	1.56	22.08
200-299	268	31.23	1.58	25.88
300-399	149	34.33	2.57	31.33
400+	25	26.73	5.33	26.65