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DISTRIBUTION OF ALBACORE TUNA SIZE BY DEPTH WITHIN THE AUSTRALIAN EASTERN TUNA AND BILLFISH FISHERY

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1. Introduction

Before 2006 albacore tuna was not considered a principal target species in the Australian Eastern Tuna and Billfish Fishery (ETBF). However, the low availability of other target species in 2006, and the successful targeting of this species with deeper set longlines, resulted to a greater targeting of albacore and a rapid increase in the annual catch. The estimated annual catch of albacore increased from around 890 tonnes in 2004 to around 2500 tonnes in 2006 (Campbell, 2009).

The catch and effort data associated with all fishing operations in the ETBF is recorded on logbooks. The current AL06 logbook used by the domestic longline fleet requests that for each species fishers record the number of fish and processed weights of the retained catch. These weights are based on visual estimates as the weights of fish are not measured at sea. Since 1997 the processor measured weights of individual fish landed in the ETBF have also been collected as part of an ongoing size monitoring program, whilst since the start of 2006 the aggregate weight (by species) of all fish landed by vessels after each trip has been recorded on a Catch-Deposal Record (CDR). This paper uses each of these data sources to ascertain if there are differences in the size of albacore caught on longline sets targeting a range of different depths.

2. Estimates based on Catch Deposal Records

Since the start of 2006 all vessels landing fish in the ETBF are required to complete a Catch Deposal Record upon returning to port. This form records, for each species, the number and total weight of fish landed. The receiver of the fish is also required to complete the form for fished received. As fish are usually landed in a processed state on both forms the total processed weight of fish landed (or received) together with the process form is recorded. A summary of the CDR data for albacore tuna landed in the ETBF is provided in Table 1. Whilst all CDR records have the weight of fish recorded, there are instances where the number of fish has not been recorded. There were also several instances where there was Receiver data for a trip and no Operator data and vice versa. In total there are 4,127 distinct CDR catch records for albacore.

Table 1. Summary of the CDR data collected in the ETBF.

Data Type		Number of CDR Records	
Number of Fish	Weight of Fish	Receiver Data	Operator Data
Yes	Yes	3,308	3,609
No	Yes	736	404
Yes	No	0	0

Total Number of Records	4,044	4,013

All fish weights recorded on the CDR data were converted to whole weights using an appropriate processed-to-whole weight ratio. Furthermore, where possible the CDR records relating to individual fishing trips were linked to the logbook data which records details of each fishing operation undertaken during each trip. In total, 4,019 CDR records (97.4% of the 4,127 CDR records) were linked in this manner to 3,787 fishing trips. The distribution of the linked CDR records and trips by year is shown in Table 2. Note, in order to account for fishing trips where the start and finish date of the trip are in different years, the year of a fishing trip was taken to be the year in which the majority of fishing operations on that trip occurred. Where there were an equal number of fishing operations, the latter year was chosen.

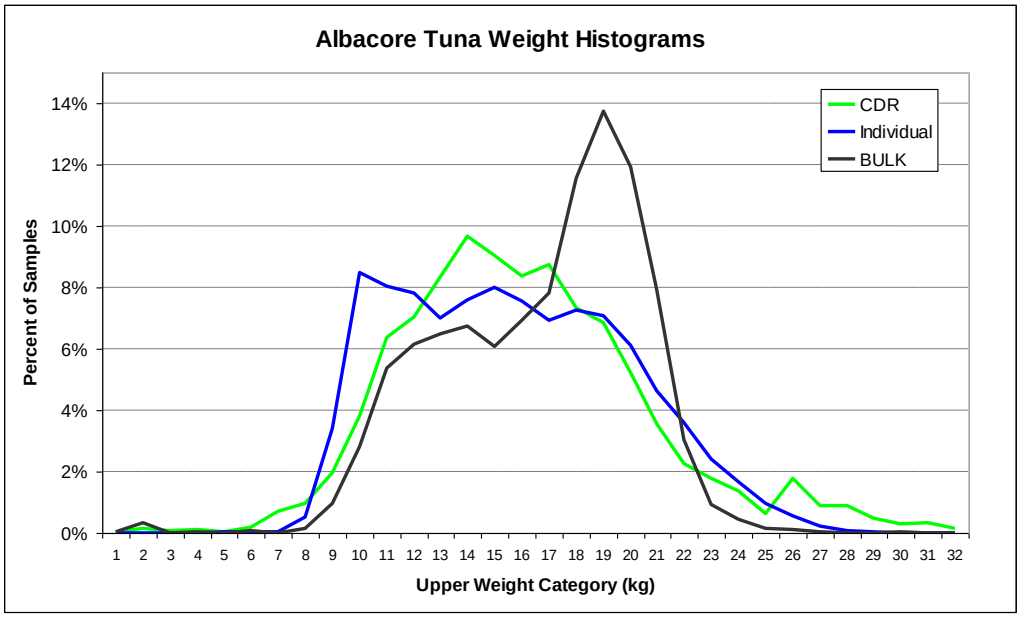
Table 2. Number of CDR records linked to logbook data and the number of related fishing trips by year.

Year	Linked Data		Selected Trips
	Number of CDR records	Number of Fishing Trips	Number of Fishing Trips
2005	1	1	0
2006	1,419	1,369	1005
2007	1,293	1,216	913
2008	1,302	1,197	928
2009	4	4	4
Total	4,019	3,787	2,850

The receiver weight data (in comparison to the operator supplied weight data) is assumed to provide a more accurate measure of the total weight of fish landed per trip as the latter are an estimate whilst the former are based on the measured weights of fish received. As such, for this analysis only the receiver data was used to ascertain the mean weight of albacore landed per trip. Unfortunately, this excluded the data from 740 trips for which the number of albacore had not been recorded by the receiver.

The distribution of mean weight of albacore for the 3,047 trips for which receiver data was available is shown in Figure 1. For comparison, the distribution of the 40,935 whole weights individual albacore measured between July 2005 and December 2008 is also shown, together with the distribution of the mean weights of albacore from 7,932 bins of albacore measured in bulk (representing 190,845 fish). The distribution of CDR mean weights indicates that for the majority of trips (92.6%) the mean weight was between 8 and 25 kg. However, the distribution of mean CDR weight is seen to extend outside the range of the other two distributions, especially at the upper end. An inspection of the receiver data for these trips indicated that the recorded number of fish received is likely to be erroneous. Whilst it was possible to correct some of these records (using the operator and logbook records) the trips for which the mean weight of albacore was outside the range of 8-25 kg were excluded from the ongoing analyses. This left a total of 2850 trips (cf. Table 2) having a combined received catch of 340,643 albacore.

Figure 1. Distribution of the mean weight of albacore tuna received from the 3047 trips for which CDR data is available. Also shown is the distribution of mean albacore weights from the 7936 bins of albacore measured in bulk and the distribution of individual whole weights for 40,935 albacore measured in the ETBF.



For each trip, the following additional information was added using the information recorded in the logbooks for each trip:

1. Quarter – as with year, in order to account for fishing trips which start and finish in different quarters, the quarter was taken to be that in which the majority of fishing operations on that trip occurred.
2. Mean Location of catch – to ascertain a unique catch location for each trip, the albacore catch (as measured by the number of albacore recorded in the logbook) weighted mean location of each fishing operation was calculated. This mean location was then used to identify the area in which the fishing took place as follows:

Northern	Mean location north of 25°S
Central	Mean location between 25°S and 30°S
Southern	Mean location south of 30°S

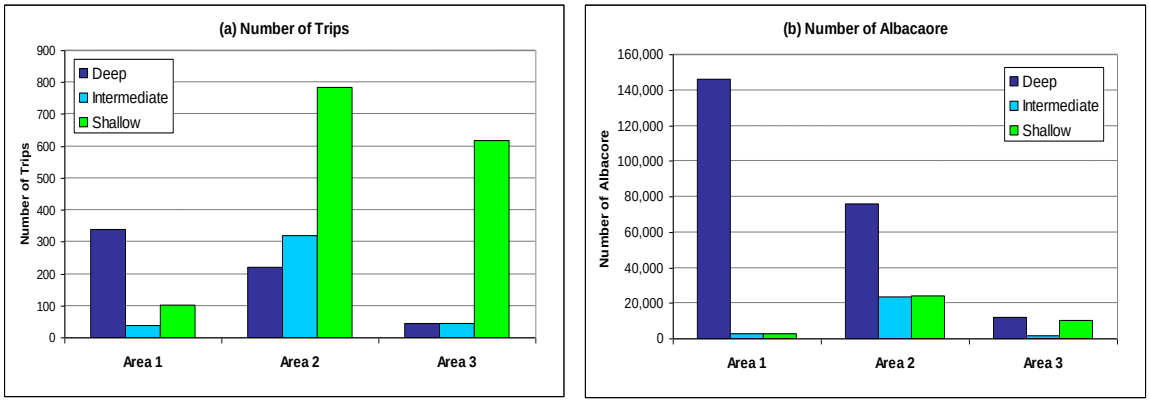
3. Range of hooks-per-float (HPF) deployed on the fishing operations during the trip. Each trip was then classified according to the range of HPF used across all the associated fishing operations as follows:

Shallow Depths	If the range of HPF used was between 4 and 11
Intermediate Depths	If the range of HPF used was between 12and 20
Deep Depths	If the range of HPF used was between 21 and 40
Mixed Depths	None of the above

Note HPF is taken as a proxy for the depths targeted by the fishing operation.

As there was only a small amount of data for 2009, and as the analysis is aimed at determining the mean catch size by depth class, the data from the 4 trips in 2009 and the 337 trips having a mixed depth classification were not used in the subsequent analysis. The distribution of the remaining 2,312 trips included in the analysis across each Year, Quarters, Area and Depth stratum is shown in Table 3 while the distribution of trips across each Area and Depth stratum is shown in Figure 2.

Figure 2 Distribution of (a) trips and (b) number of albacore caught, used in the analysis across each Area and Depth stratum.



A number of analyses were undertaken within a range of different spatial strata. Within each stratum the mean size of albacore was calculated for each Depth class by dividing the CDR estimated total weight of albacore caught in that stratum and depth by the total number of albacore caught in the same stratum and depth. Each analysis was conducted over the time-series of the 12 quarters covering the years 2006-2008 in order to account for seasonal and inter-annual changes in albacore sizes. Results are only presented for those quarter-region-depth strata where the number of albacore caught was greater than 50.

1. Combined Areas

   In this analysis the data for each of the three Areas defined above were aggregated with the mean size of albacore calculated for each quarter and depth stratum. The results, shown in Figure 3a, indicate there is no difference in mean albacore weights caught on Shallow and Intermediate gears but suggests that larger albacore are generally caught on Deep-setting gears in the first and last quarter of each year. However, if there is a change in mean weight of albacore with latitude, with larger albacore generally caught in the northern sector of the ETBF, then this result may be influenced by the fact that the majority (56.2%) of all Deep sets occurred in the northern area whilst only 9.4% and 6.8% of the Intermediate and Shallow sets occurred in this area. Indeed, the average across the 12 quarters of the mean weight of albacore caught each quarter in the northern area of 17.7kg is significantly greater than the average of the mean quarterly weights for the central and southern regions (14.3kg and 13.9kg respectively).

2. By Area

   To overcome the possible bias of the previous analysis, the analysis was repeated for each of the three defined areas separately and the results are shown in Figures 3b-d. In the central and southern areas there is no apparent difference in mean albacore weight across the three depth strata. On the other hand, there is some evidence that larger fish were caught on deep sets in the northern area during the first two years, but this difference is not apparent during the third year.

Table 3. Distribution of the trips included in the analysis across each Year, Quarters, Area and Depth class.

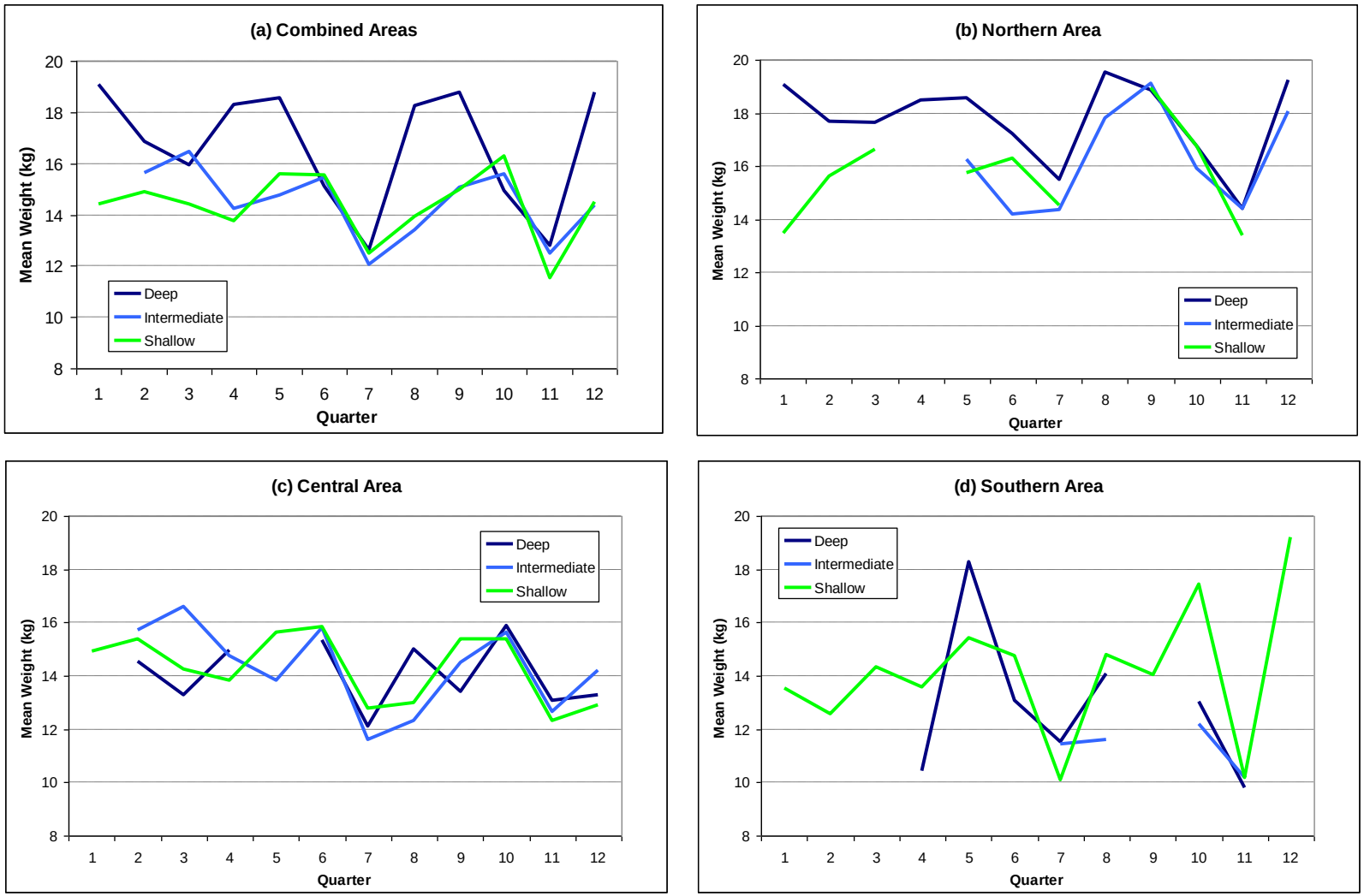
(a) Number of Trips

QTR	AREA	DEPTH CLASS	2006	2007	2008	Total
1	North	Deep	12	40	28	80
		Intermediate	0	4	4	8
		Shallow	18	13	5	36
	Central	Deep	0	0	6	6
		Intermediate	1	4	23	28
		Shallow	85	87	39	211
	South	Deep	0	1	5	6
		Intermediate	0	1	2	3
		Shallow	54	45	50	149
2	North	Deep	58	24	5	87
		Intermediate	1	1	9	11
		Shallow	15	10	19	44
	Central	Deep	17	26	13	56
		Intermediate	6	18	79	103
		Shallow	134	85	41	260
	South	Deep	1	9	3	13
		Intermediate	0	0	13	13
		Shallow	77	52	65	194
3	North	Deep	59	13	8	80
		Intermediate	2	5	5	12
		Shallow	9	5	6	20
	Central	Deep	53	66	18	137
		Intermediate	20	28	73	121
		Shallow	92	56	38	186
	South	Deep	0	4	6	10
		Intermediate	0	1	15	16
		Shallow	44	46	49	139
4	North	Deep	55	15	22	92
		Intermediate	1	3	3	7
		Shallow	3	0	0	3
	Central	Deep	11	8	2	21
		Intermediate	8	16	44	68
		Shallow	59	36	34	129
	South	Deep	2	11	2	15
		Intermediate	1	8	4	13
		Shallow	56	52	27	135
Total			954	793	765	2512

(b) Number of Albacore

QTR	AREA	DEPTH CLASS	2006	2007	2008	Total
1	North	Deep	6169	24284	3012	33465
		Intermediate	0	51	62	113
		Shallow	124	82	51	257
	Central	Deep	0	0	55	55
		Intermediate	1	92	375	468
		Shallow	948	741	494	2183
	South	Deep	0	896	26	922
		Intermediate	0	6	10	16
		Shallow	410	179	433	1022
2	North	Deep	23584	6675	344	30603
		Intermediate	28	219	1062	1309
		Shallow	265	291	993	1549
	Central	Deep	8155	5892	1307	15354
		Intermediate	116	882	8099	9097
		Shallow	4668	3988	2578	11234
	South	Deep	16	7683	957	8656
		Intermediate	0	0	286	286
		Shallow	1079	1593	1659	4331
3	North	Deep	32532	5596	1614	39742
		Intermediate	280	657	586	1523
		Shallow	198	208	472	878
	Central	Deep	21549	30733	5566	57848
		Intermediate	457	3233	9159	12849
		Shallow	2765	2759	3464	8988
	South	Deep	0	272	1444	1716
		Intermediate	0	93	1107	1200
		Shallow	617	524	2720	3861
4	North	Deep	32243	3600	6718	42561
		Intermediate	5	99	64	168
		Shallow	18	0	0	18
	Central	Deep	1612	390	539	2541
		Intermediate	154	238	895	1287
		Shallow	1025	506	485	2016
	South	Deep	114	827	20	961
		Intermediate	60	98	49	207
		Shallow	441	557	166	1164
Total			139633	103944	56871	300448

Figure 3. Time-series of mean whole weights of albacore tuna caught within various spatial and depth strata within the ETBF.



3. Analysis of Individual Processed Weights

Individual processed weights of the principal target species have been collected from processors in the ETBF since mid-1997 including the individual weights of 176,237 albacore. As with the CDR data, these data relate to albacore landed at the end of a fishing trip and can be linked back to the logbook data for that trip. However, whilst the CDR data is assumed to be a complete record of fish landed and processed by receivers at the completion of all ETBF trips, the individual weight data only relates to a sub-sample of trips and a sub-sample of the fish landed for those trips.

The individual weights recorded for each of the trips were linked back to the quarter, area fished and depth-class in the same manner as the CDR data. As there was little deep setting in the ETBF before 2006, the analysis is again limited to the period 2006-2008 and those trips which fished a mixed range of fishing depths (as defined previously) were also excluded. This left a total of 765 trips for which there were 31,789 individual albacore weights.

For each quarter, area and depth stratum the proportional of small, prime and large-sized albacore caught in each stratum was calculated. Each percentage was calculated as the total number of fish in a given size class caught in a stratum divided by the total number of fish caught in that stratum, i.e. the numbers were summed over all trips. As with the previous analyses, calculations were limited to those strata where the number of albacore was at least 50. As the majority of albacore weights recorded during this period were whole weights (with the processed state of the other fish usually not recorded), the definition of small, prime and large sized albacore was based on dividing the total histogram of the 41,545 measured albacore whole weights for this period (c.f. Figure 1) into equal thirds, i.e.

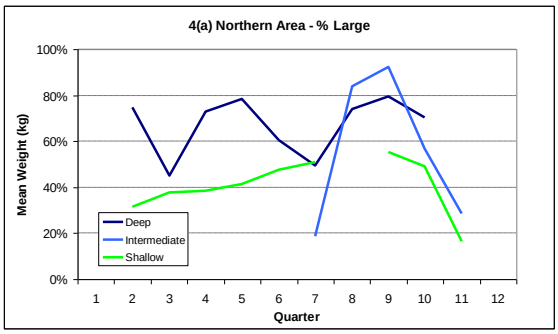
1. Small albacore	all weights within the lower third	Whole-wt<12.0 kg
2. Prime albacore	all sizes within the middle third	12.0≤Whole-wt≤16.3kg
3. Large albacore	all sizes within the upper third	Whole-wt >16.3kg

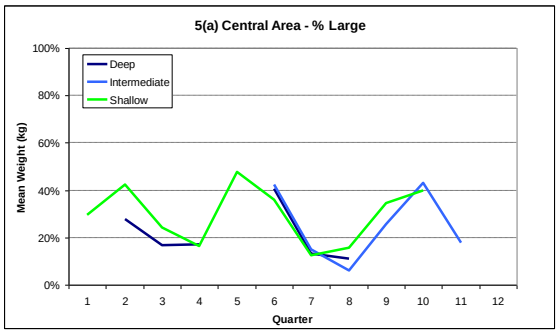
The time-series of the percent of small, prime and large-sized fish caught within each Depth-class for the northern and central regions are shown in Figure 4a-c and Figures 5a-c respectively. No results are shown for the southern region as there was insufficient data (there were only 4 quarter-depth strata where the number of fish was greater than 50). The results are consistent with those for the analyses based on the CDR data. First, there is little evidence to suggest any consistent difference in the percentage of each size class caught within each Depth class within the central area. Second, within the northern area the results indicate a greater proportion of large sized albacore relative to small sized albacore are caught on Deep sets, with a corresponding reversal of this situation for Intermediate-depth sets.

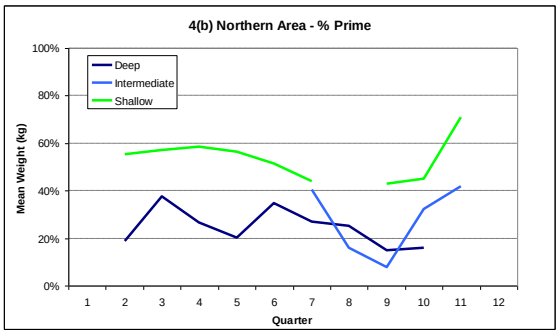
4. Discussion

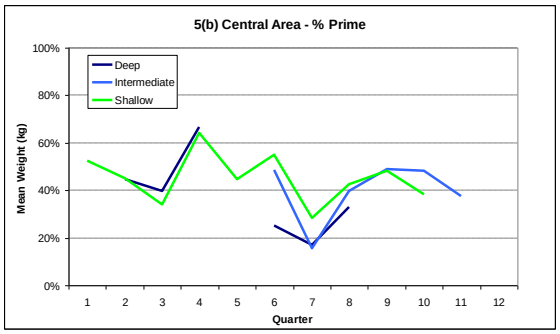
Catch-at-size data is an important input to stock assessments conducted on the principal tuna and billfish species targeted in the Western Central Pacific Ocean. These data are used to ascertain the age-class of the fish caught in the fisheries and are used in the stock assessment to help provide an estimate of the age-class structure of the fish population being assessed. It follows then that changes in the age-classes of the fish caught in the fisheries are often interpreted as indicating a change in the underlying age-structure of the available fish population. As this relationship can have

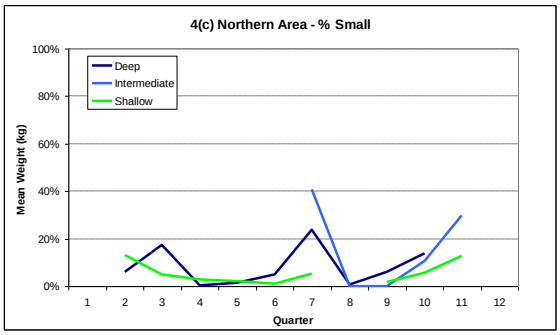
Figures 4 and 5.Ttime-series of the percent of small, prime and large-sized fish caught within each Depth-class for the northern and central areas respectively.

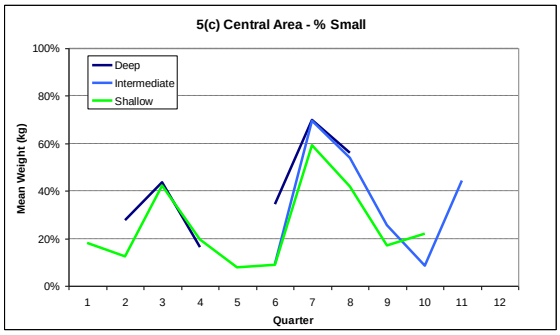








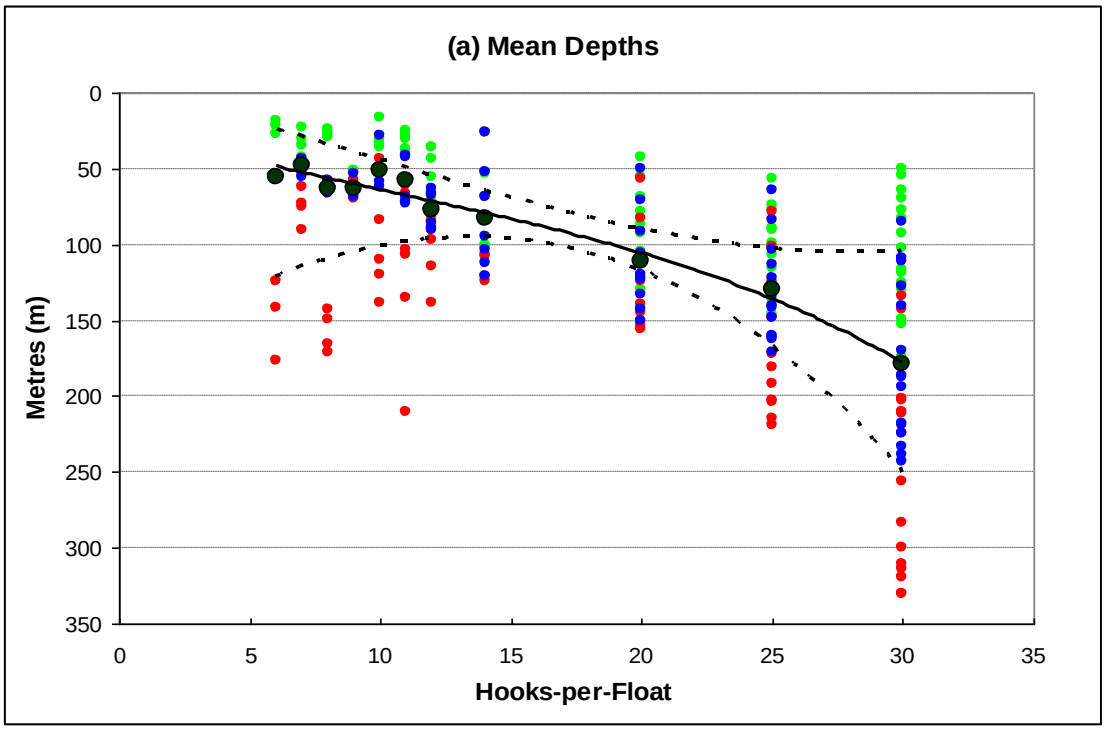




important consequences for assessing the status of the stock it is important that other factors influencing changes in the age-structure of the fish caught in the fishery are accounted for.

In this paper some preliminary evidence has been presented which indicates that the size-class of albacore caught in the Australian longline fishery operating off eastern Australia can be influenced to some extent by both the area fished and the depths targeted by the longline gear. Larger albacore are caught in the northern area above -25^{o}S and this is consistent with the known movements of this species. However, during 2006 and 2007 there is also some evidence to suggest that the larger fish in this northern region were more likely to be caught on longlines deploying a greater number of hooks-per-float. Observations using Temperature-Depth-Recorders indicate that, on average, gears deploying 20 or more HPF in the ETBF generally fish depths significantly greater than those deploying fewer HPF (c.f. Figure 6 taken from Campbell and Young 2009). However, why these observed differences are not also evidence in the results for 2008 remains uncertain, but may be due to differences in the distribution of albacore in the water column in response to inter-annual differences in temperature-at-depth. Further research is required to investigate these results more fully. Nevertheless, if these results can be shown to be more generally true across the

Figure 6. Average (blue), minimum (green) and maximum (red) of the mean depth across all TDR observations for each hook position and HPF configuration. Cubic splines are fitted to each set of data, with the solid line indicating the fit to the averages. The "Indicative Depths" for each gear configuration (the mean of the average observed depth across each hook-number) are also shown in (a) as large black dots.



fisheries catching albacore in the WCPO, and given the previous discussion, then it would be important when undertaking a stock assessment to also account for differences in the size-structure of the catch due to differences in the gears used in the fishery (as well as area fished) as differences in the size-structure of the catch may not be due to changes in the underlying age-structure of the population.

References

Campbell, R. (2009) Summary of Catch and Effort Information pertaining to Australian Longline Fishing Operations in the Eastern Tuna and Billfish Fishery. Information paper presented to the meeting of the ETBF Resource Assessment Group, held 3-4 March 2009, Hobart.

Campbell, R., Young, J. (2009) Determination of Effective Longline Effort in the Eastern Tuna and Billfish Fishery. Final report for project 2005/004 to the Fisheries Research and Development Corporation, Canberra, 141pp.