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Domestic Australian Longline Fishing Methods and the Catch of Tunas and Non-Target Species off North-Eastern Queensland

by

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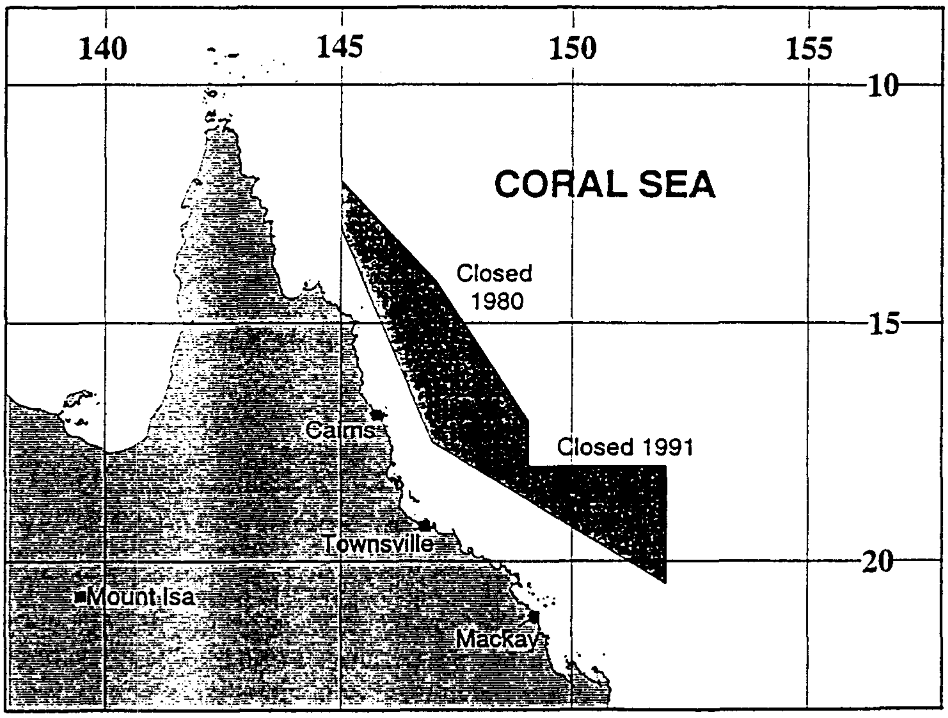
1. Introduction

The Coral Sea region of the Australian Fishing Zone (AFZ) is an area covering more than 750,000 square kilometres (Caton and Hampton, 1991). This region also includes the broadest section of the AFZ, with the outer boundary extending out to over 1000 kilometres offshore from the Queensland coast. The major tuna and billfish species which occur in this region are of considerable interest to both the domestic commercial and recreational/charter-boat sectors of the Australian fishing industry as well as commercial Japanese longliners.

Following the declaration of the AFZ on 1st November 1979, a number of restrictions have been placed on the operations of Japanese longliners fishing in this region resulting in a large area which is now permanently closed to these vessels. These restrictions were intended to reduce the interaction between Japanese longliners and the northern Queensland recreational and charter boat fisheries which target billfish species within this region. The restricted zone (shown in Map 1 below) has become known as Area E and has an area of approximately 172,000 square kilometres. Note: the Great Barrier Reef Marine Park occurs inshore of Area E in which all longlining is presently prohibited.

Map 1. Map showing the region known as Area E off the north-eastern Queensland coast. The dates indicate the years in which each section was closed to Japanese longliners.



Since 1987 a domestic longline fishery operating out of Cairns has developed targeting yellowfin and bigeye tunas. This fishery has undergone considerable expansion in the last few years with a combined catch of yellowfin and bigeye in recent years of approximately 400 tonnes. To date thirteen permits have been granted which allow vessels to operate within Area E, though only eight vessels are presently operating there.

While the commercial fishery does not target billfish, the potential for significant interactions between the domestic longline fishery and the recreational fisheries within Area E over the catch of billfish has become a major management concern in recent years. Poor catches of black marlin by the recreational sector off Cairns in late 1994 triggered concerns that local abundance of black marlin was becoming depleted due to the by-catch of this species by the domestic longliners. This concern led to calls for the cessation of all commercial longlining within Area E and pressure to prohibit the taking of all marlin species by commercial operators. In response the Australian Fisheries Management Authority (AFMA) identified the interaction between the commercial and recreational sectors of the Eastern Tuna and Billfish Fishery as an important research area that needed to be addressed. A preliminary analysis of the situation by the Billfish Assessment Group (Campbell et. al. 1996), however, highlighted the complex nature of this fishery interaction issue and made a number of recommendations for future research. One of the conclusions was that in order to gain a better understanding of this issue, the collection of verified catch and effort statistics would be required from all sectors catching billfish in this region.

Past studies into the catch of billfish in this region have focused on the analysis of historical Japanese longline data (Williams et al. 1993, Ward 1996) but may have little relevance to the operations of the present day domestic tuna fishery as the nature of the longline operations is in many regards quite different. As a result, while there exists much anecdotal opinion concerning the catch of billfish by domestic longliners, there is very little hard data on which to base sound management decisions. In order to overcome this lack of information, this project focused on the collection of observer verified catch and effort statistics from a number of the domestic longline vessels operating within Area E. By monitoring the nature of the catching process by means of electronic monitors attached to the fishing gear, the project also focused on the evaluation of the longline catch in relation to the vertical distribution of the tuna and billfish resources within this region. The possibility of habitat segregation of the tunas and billfish in this region may provide some assistance in developing practical means to minimise the by-catch of marlin species by the domestic longline fleet and in turn help mitigate the interaction between the different fishing sectors.

2. Project Details

Through the placement of observers on domestic longliners operating within Area E the following primary objectives were to be achieved:

1) provision of verified catch and effort data pertaining to the domestic longline fishery operating within Area E.
2) evaluation of the catch of the principal tunas and billfish species in relation to different gear configurations.
3) evaluation of the time of capture of the principal species caught.
4) evaluation of the vertical distribution of the tuna and billfish species caught.
5) evaluation of the by-catch of billfish species by the commercial tuna longliners operating within Area E.

Two surveys were undertaken. The first survey was during spring 1995 (12th October - 13th December) when two observers were placed aboard vessels operating within Area E. The second survey was undertaken during winter 1996 (16th May - 22nd August) when only a single observer was deployed. All fishing activities were observed and for each longline set the following data pertaining to the catch and effort were collected:

i) setting and hauling details - times, positions, environmental conditions.
ii) gear details - number of hooks and number of hooks between buoys.
iii) catch details - species name, time of landing, life-status, hook number of catch, retained or discarded.

The timing of the two surveys was to observe the seasonality in the fleet behaviour and the catch. The first survey coincided with a period in which spawning aggregations of tuna occur during the spring months (usually around the full moon). As such the fishing strategies adopted by the vessels during this period may differ in some aspects to those strategies adopted during other seasons. For this reason, and due to the seasonality in abundance of billfish within Area E, the second survey was undertaken during the winter months.

Together with the collection of the usual catch and effort information mentioned above, electronic monitors were used to record more detailed information on otherwise unobservable aspects of the fishing process. Temperature-depth recorders were used to monitor the depth of the longline and the temperature profile of the water column. The information on fishing depth was combined with the distribution of capture hook position to evaluate the distribution of the principal species caught in the water column. The hook monitors used during the survey were archival tags developed as part of the southern bluefin tuna stock assessment project carried out by CSIRO Division of Fisheries (Ward, 1995). At the start of each longline set the monitors were taped onto hooks (without bait) and recorded the depth and associated temperature of the hook at one minute intervals for the duration of the set. On average four monitors were deployed during each set.

Hook-timers were also deployed to provide information on the time of fish capture. Two hundred timers were constructed for the survey by technicians at CSIRO Division of Fisheries in Hobart. In brief, each timer consists of plastic resin cast around a battery-powered microchip clock controlled by a magnet within a surrounded sheaf (Somerton et al, 1988). Initially 100 timers were deployed on each vessel but due to losses, the failure of some units, and the practicalities of deploying the units along the line, the number of timers deployed on each set was usually around 50. Each hook-timer was deployed at the top of a branch-line so that when a fish strikes the bait and/or is caught on the hook below, the line connected to the hook removes a magnet within the surrounding sheaf. Removal of the magnet starts the clock which then records the time elapsed from when the bait and /or hook was bitten until the hook (and hopefully the fish) are retrieved during the hauling of the line. Knowing the time the hook was placed in the water allows calculation of the soak time of the hook and the bait before being bitten.

A summary of the observer coverage during each survey is given in Table 1. For the spring survey the observer coverage of total fleet effort within Area E (number of hooks deployed) was 29 percent, while for the winter survey the observer coverage was around 7 percent. The lower observer coverage during the winter survey was principally due to a combination of the halving of the observer coverage during any month (ie. the use of only a single observer for four months compared with the use of two observers for two months) and a doubling in the total effort of the fleet between surveys.

Table 1. Details of observer coverage.

Observer Coverage	Spring Survey, 1995*	Winter Survey, 1996
Months	November-December	May-August
Number of Trips	11	8
Observed Boats	6	4
Observed Boat Days	44	34
Number of Observed Sets	73	36
Number of Observed Hooks	22,712	20,493
Hooks with Timers	2,217 (9.8%)	1,743 (8.5%)

*One observer trip was undertaken in october, 1995

Both the hook monitors and hook-timers were deployed in a structured manner to ensure an adequate coverage of the various hook depths and configurations of the lines. During the spring survey the observed vessels all fished in a region less than 120 nm from Cairns, while during the winter months some of the vessels fished outside Area E and further north.

3: Details of Fishing Operations

3.1 Gear

All observed vessels were between 18 and 20 metres in length, and most vessels were less than 4 years old having been purpose built for longlining. The oldest vessel was 17 years of age and had been converted for longlining from an old South Australian tuna poling vessel. All vessels had a complement of four (1 skipper and 3 deck crew) and were equipped with the usual electronic navigation, communication and fish locating equipment.

A listing of the gears used on the observed vessels during the first survey is given in Table 2 (the details are similar for the second survey). All boats used nylon monofilament mainlines and each vessel was equipped with a hydraulically controlled drum. The vessel speed and that of the drum were adjusted so that the rate at which the mainline was unwound from the drum matched that paid out over the stern. Not all boats had line throwers, and on those that did the line thrower often malfunctioned or there were problems caused by mainline repairs jamming in the line thrower. The line thrower, if used, was adjusted to feed the mainline over the stern of the vessel at the same rate as it was wound off the mainline drum.

Table 2. Gear characteristics used on observed vessels during the spring survey.

Characteristic	Vessel 1	Vessel 2	Vessel 3	Vessel 4	Vessel 5	Vessel 6
Mainline material	mono	mono	mono	mono	mono	mono
Mainline diameter (mm)	3	5	3-4	4	3.5	3
Buoy-line length (m)	20	15	20	10	10	10
Buoy-line material	tetron	rope	polyprop			polyprop
Branch-line length (m)	20	14	18	17	15	10
Branch-line material	mono	mono	mono	mono	mono	mono
Hooks-per-buoy	10-14	10-18	10-25	10-14	10	12
Line thrower	N	Y -	Y	N	Y	Y
Setting speed (knots)	5.0 - 5.3	-	8.1 - 9.3	-	-	6.8 - 7.9

* mono = nylon monofilament

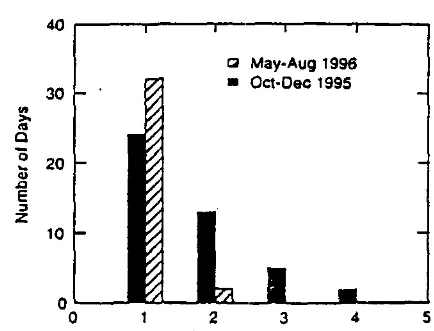
The speed of the drum could be increased when the line thrower was in use resulting in a greater rate of mainline deployment. In theory this will result in the line having a deeper catenary shape since there is more mainline between the buoys. However, on most vessels there was no standard procedure adopted during deployment. For example, there was no specific rate of line output from the vessel used in conjunction with specified distances between branch-lines to target particular depth ranges as practiced by Japanese longliners. Consequently, due to the variations in the amount of slack in the line during deployment, the final configuration of the mainline in the water would vary from set to set and between buoys within a set. Weighted swivels were used on all branch-lines, whilst the swiveling clips on at least one vessel were also weighted.

3.2 Sets per Day

Fishing practices varied considerably between vessels as did the number of sets deployed per day. There was also considerable difference in practices between the spring and winter months.

A histogram showing the number of sets deployed by a vessel per day is shown in Figure 1 on the right. During the spring months multiple sets per day were deployed by most vessels with up to four sets being

Figure 1.Days vs.Sets-per-Day

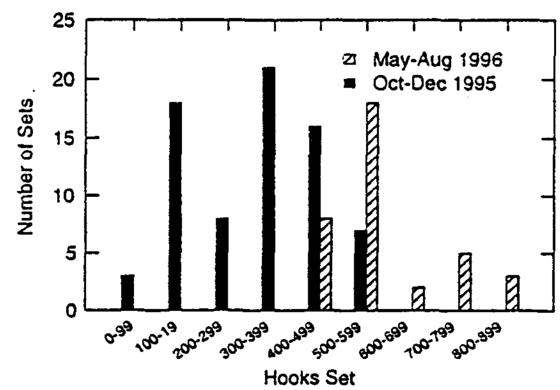


deployed during a single day. (Note that the date of a set is taken as the date the first hook was deployed.) On the other hand, during the winter survey a single set per day was preferred. Whilst there may be some variation in crew ability and the fishing practices adopted by different skippers, multiple sets per day often occurred when a good catch was obtained on the previous set and a shorter set was deployed in the same vicinity. Also, short sets were targeted on the surface aggregations which occur during the spring months.

3.3 Number of Hooks per Set

The occurrence of sets deploying different number of hooks is shown in Figure 2 below. Again there is seen to be considerable differences seen between the two surveys. Note, however, that all vessels observed during the first survey fished within Area E where the maximum number of hooks allowed to be set is 500, whilst several boats fished outside this region during the winter survey where there is no limit on the number of hooks which can be set.

Figure 2. Histogram of Sets (N) vs Number of Hooks



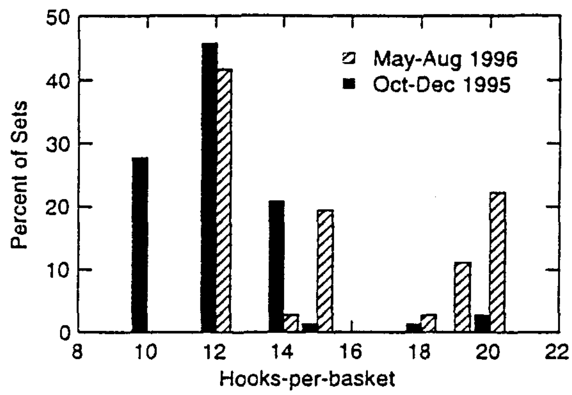
The range observed in the number of hooks deployed in a set corresponds to the strategy of deploying multiple sets per day. For example, the smaller number of hooks deployed per set during the spring survey coincides with the practice of setting multiple sets per day during this period. As mentioned previously, this practice was often adopted when re-setting on surface aggregations. Indeed, the number of hooks deployed when re-setting on these aggregations was often quite small - the minimum number of hooks deployed was 50.

Even though smaller sets were deployed when targeting aggregations, of the 73 sets observed during the spring survey only 7 deployed the maximum allowed number of 500 hooks. Even where a vessel deployed only a single set per day, the number of hooks deployed was usually less than 500. Part of the reason for the lack of sets with 500 hooks may be related to loss or damage of the gear and to problems in handling longer sets. During one trip 500 hooks were deployed during the first shot, but due to gear damage this number was unable to be deployed again. This damage was often due to large fish (sharks and billfish) interacting with the gear. These problems, if they exist, would appear to be seasonal as the number of hooks deployed per set during the winter months was usually close to 500 for all sets within Area E.

3.4 Hooks-per-Buoy

Differences in the number of hooks set between buoys is often used by Japanese longliners to target different depth strata. For domestic longliners operating within Area E a range of hooks-per-buoy were observed, though for most of the observed sets fishers set between 10 and 20. However, as no strict protocol was adopted during the deployment process, and together with problems encountered during mainline deployment, the number of hooks between buoys was not always constant within a set. Furthermore, as none of the vessels used setting timers (devices which allow attachment of hooks at equal intervals of time as the mainline is deployed), the distance between branch-lines also varied both between and within sets. On one vessel branch-lines were attached to the mainline close together whenever surface activity was great.

Figure 3. Histogram of sets (%) versus number of hooks deployed per buoy.



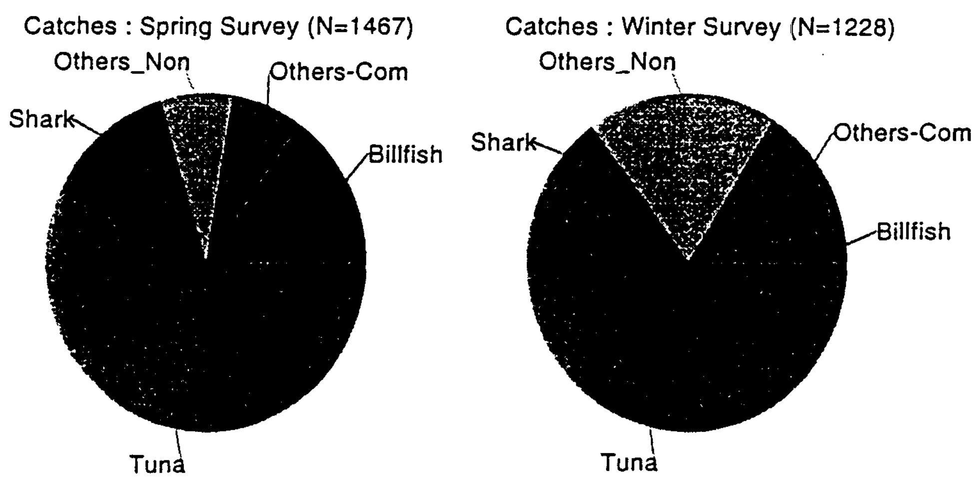
Whilst it was not possible to record the number of hooks deployed between every set of buoys, the observers estimated the average number of hooks-per-buoy. The frequency of these estimates is given in Figure 3 on the left. (Note, one set contained a combination of 10 and 25 hooks between buoys and is not included in this result.) While there are seasonal differences seen in the configurations used, with a tender to set more hook-per-buoy during the winter months, the most comon configuration deployed during each season was 12 hooks-per-buoy.

4. Catch Details

4.1 Total Catch

All hooks were observed on retrieval during each survey and a total of 1,467 and 1,228 fish were observed caught during the spring and winter surveys respectively. A breakdown of the catch for each survey by category is given in Figure 4 and Table 3 below. A complete listing of the number of fish caught by species during each survey is given in the Appendix. For both surveys tunas comprised the largest portion of the catch, accounting for 57 and 58 percent respectively. For the spring survey billfish (15%) and sharks (13.5%) were the next most common catch, while for the winter survey other non-commercial (19%) and other commercial species (13%) were the next most common.

Figure 4. Catch composition of observed catches during the two surveys.



Yellowfin tuna was the most common tuna caught during both surveys accounting for about two-thirds of the catch of tunas. Bigeye tuna, being another target species, comprised around 30 percent of the catch during spring but only around 12 percent during winter, when more

Table 3. Percentage composition of the total observed catch during each survey

Category	Spring Survey		Winter Survey	
Tunas	56.8		58.3	
- Yellowfin tuna		*64.7*		*63.0*
- Bigeye tuna		*29.6*		*11.9*
- Albacore tuna		*2.8*		*19.6*
- Skipjack tuna		*3.0*		*5.6*
Billfish	15.0		3.3	
- Black marlin		*98.2*		*0.0*
- Blue marlin		*0.4*		*0.0*
- Broadbill swordfish		*1.4*		*90.2*
- Striped marlin		*0.0*		*4.9*
- Spearfish		*0.0*		*4.9*
Sharks	13.5		6.4	
Others - Commercial	7.4		19.1	
Others - Non commercial	7.4		12.8	
Total	100%		100%	

albacore tuna was caught. The seasonality in the catch composition is most marked in the differences in the billfish catches. During the spring survey the billfish catch was almost totally comprised of black marlin whilst during the winter survey broadbill swordfish was the most commonly caught billfish.

Overall, 34 different species were identified in the catch during the spring survey with 35 species identified during the winter survey.

4.2 Retention Practices

Of the 1,467 fish caught during the spring survey, 875 fish were observed to be retained or finned, being 60 percent of the catch. Of the fish retained, 99 (mostly sharks) were finned (11.3 percent of the retained catch and 6.7 percent of the total catch) and 5 were kept for vessel consumption. Of the 1,228 fish caught in the winter survey, 799 were retained or finned (65 percent of the total).

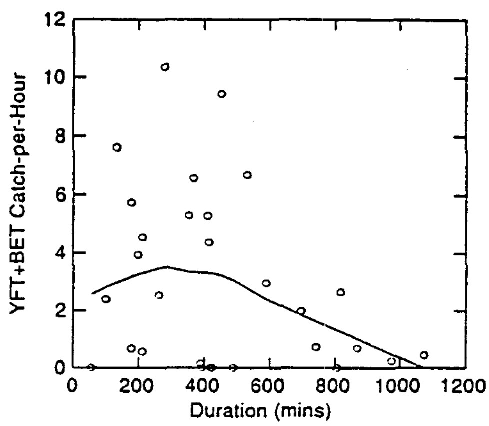
Of the target species, 99 yellowfin tuna (18.4 percent of the total yellowfin tuna catch) and 78 bigeye tuna (32 percent of the total bigeye tuna catch) were not retained during the spring survey. For the winter survey, 37 yellowfin tuna (8.2 percent of the total yellowfin tuna catch) and 6 bigeye tuna (7.1 percent of the total bigeye tuna catch) were not retained. Fish were not retained if they were deemed to be of a non-commercial size or if damaged due to predation. Damage was often due to attacks on the hooked tuna by sharks or billfish and sometimes by whales (leaving only the head).

4.3 Catch Rates

The average catch rate over the spring survey period, expressed as the number of fish per 1,000 hooks, was 64.6 for all fish caught and 38.5 for retained or finned fish. Catch rates for yellowfin tuna, bigeye tuna and black marlin were 23.7, 10.8 and 9.5 respectively. Similar catch rates were observed in the winter months, being 59.9 for all fish and 39.0 for retained or finned fish. For yellowfin tuna, bigeye tuna and black marlin were 22.0, 4.2 and 0.0 respectively

While no strong relation was found between catch rates and the number of hooks deployed, for yellowfin and bigeye tunas there appeared to be a decrease in catch rates with increasing set duration. As a fisher will attempt to maximise their return in the time spent fishing, the catch rates per unit time was investigated further. In Figure 5 on the right, the combined number of yellowfin and bigeye tunas caught per hour is plotted against the total duration of each set. (Note, only the data for those sets within a three week period during the spring survey are used here, as the average catch rate of tunas was found to be reasonably constant during these weeks indicating a relatively constant abundance during this period.) In general there is seen to be an increase in the catch-per-hour with increasing set duration for the first 500 minutes, followed by a decrease in catch-per-hour for sets of longer duration. This result may imply that there may be an optimal set duration in relation to the catch rate attained. A similar result was found for the winter survey, though the optimal set duration was longer, being around 750 minutes. The fact that such an optimal set duration may exist during any season may be due to a number of reasons. For example, the loss of bait effectiveness over time, local depletion of available fish, together with a possible increase in the instance of hooked fish managing to escape may result in a decrease in catch rates for extended soak times.

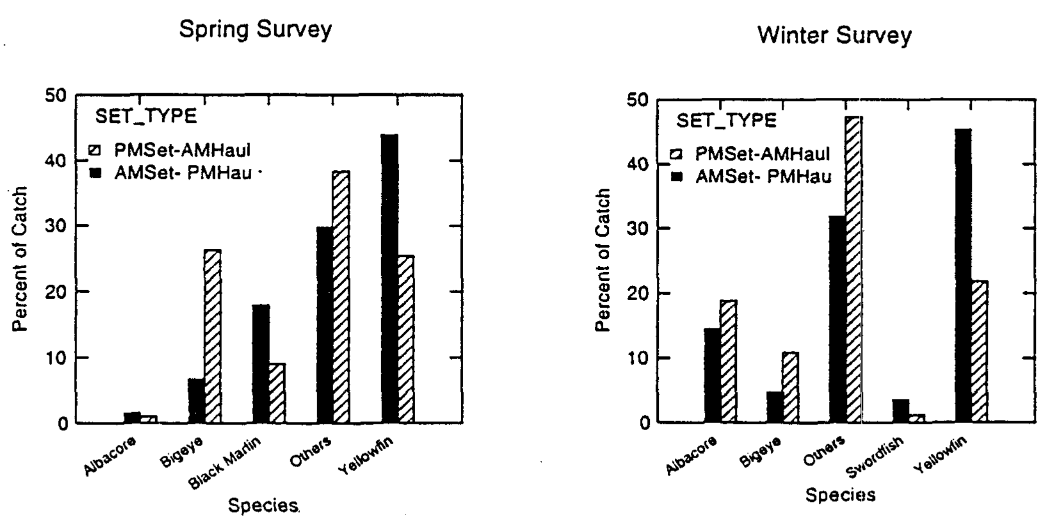
Figure 5. Catch-per hour vs. Set Duration



4.4 Catch versus Time-of-Deployment

Diel patterns in the behaviour of the target and non-target species may affect their availability to the fishing gear. In particular, it is of interest to compare the catch composition (and catch rates) of sets deployed during the day against those deployed during the night. Although the times of hook deployment and hook retrieval were dispersed over a range of times during the day and night, the majority of the sets were classified into two types. The first type were those set in the morning (4am-noon start) and hauled later in the day (1pm-midnight finish), while the second type were those set in the afternoon (2pm-8pm start) and

Figure 6. Comparison of catch comparison for day versus night sets.



hauling the next morning (1am-10am finish). A comparison of the species composition for these 'day' versus 'night' sets is given in Figure 6 above for each of the surveys.

For both surveys, while the catch is predominately yellowfin tuna for sets during the day, 'other' species are the dominant catch for the night sets. Secondly, the proportion of bigeye tuna is greater for night sets than for day sets, and a concomitant increase in catch rates (not shown) for the night sets indicates an increase in the vulnerability of this species during night sets. On the other hand, the contribution of black marlin to the total catch decreases during the night sets, indicating a general decrease in their vulnerability during the night.

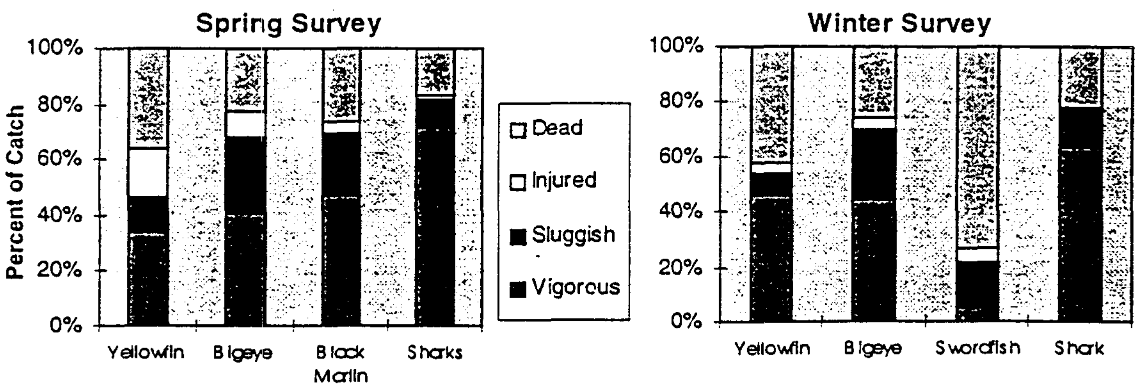
4.5 Life-Status

The life-status of most fish was observed upon retrieval during each survey with the life-status of each fish being categorised as one of the following:

i) Alive and vigorous
ii) Alive and sluggish
iii) Alive but injured
iv) Dead

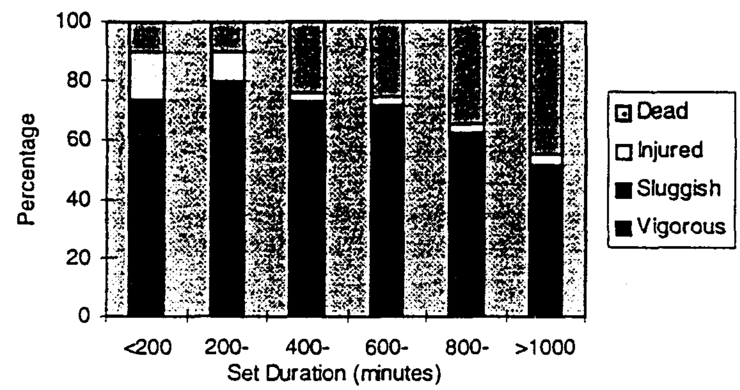
The most common source of injuries to fish were due to shark and marlin attacks on hooked tuna. The occurrence of damage to tuna was seen as being more common when setting on tuna aggregations as sharks and marlin were commonly associated with these aggregations. One observer noted that the smaller the size of the tuna, the more prone it was to attack. It was also observed that tuna captured on the shallower hooks, ie those closest to the buoys, were usually more prone to attack. Billfish were seen as being responsible for most of these attacks. Marlin sometimes regurgitate hooked tuna when they feel the tension of the line. This usually leaves the small tuna considerably damaged, if not slightly digested.

Figure 7. Proportion of the principal catch species by life-status upon retrieval.



For the principal species caught, the percentage of fish within each of the above categories is shown in the Figure 7. For yellowfin tuna, 46 and 54 percent were classified as alive and vigorous or alive and sluggish on the respective surveys. Bigeye tuna showed a greater resilience with around 70 percent of the retrieved fish being either alive and vigorous or alive and sluggish. Black marlin also displayed a greater resilience than yellowfin with 48 percent of the landed catch being classified as alive and vigorous and 22 percent classified as alive but sluggish. Only 4 percent were injured and 26 percent classified as dead. On the other hand, swordfish caught during the second survey showed the least resilience, with nearly 80 percent categorized as dead or injured. At percentage of sharks described as alive was high for both surveys.

Figure 8. Life Status of Black marlin vs Set Duration



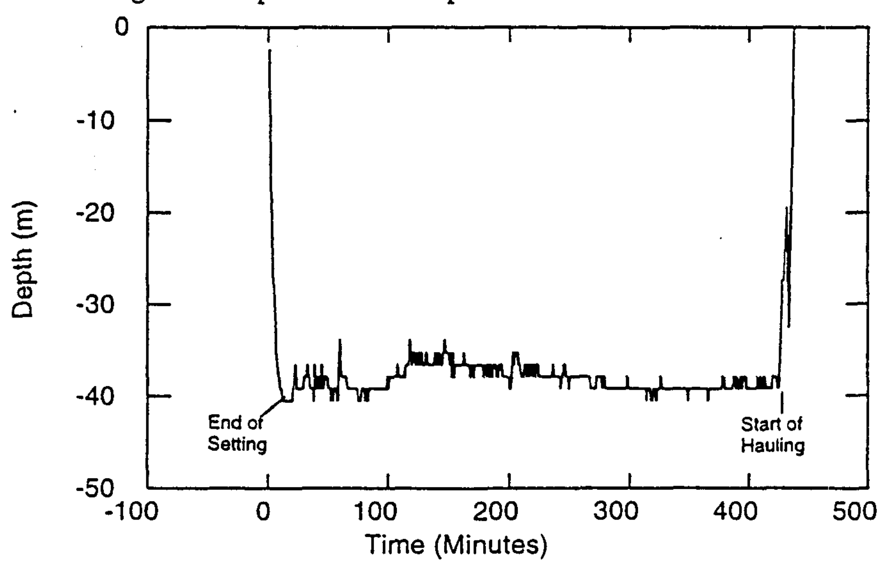
Hook restrictions usually entail a shorter set duration and consequently a shorter time on the hook for fish caught. The observer data for each survey indicated a strong relationship between the percentage of yellowfin tuna and black marlin classified as alive upon release and the duration of a set. The result for the black marlin caught during the spring survey is shown in Figure 8 above. The probability of a black marlin being retrieved alive is seen to increase significantly as the duration of the set decreases. For example, as the duration of a set decreases from 1000 to greater than 200 minutes, the percentage of black marlin dead on retrieval decreases from 44 to 10 percent. Similar results were observed for other species. For yellowfin tuna (not shown) the previous percentage decreases from 50 percent to around 16 percent.

5. Catch versus Fishing Depth

5.1 Example

Information on the depth of the fishing gear and the corresponding water temperatures at these depths was collected from the hook monitors which were placed on selected hooks. An example of the depth-versus-time data obtained is shown in the Figure 9 below. In this case the hook is seen to descend rapidly to the fishing depth of around 40 metres where the hook remains for the duration of the soak before being rapidly hauled.

Figure 9. Depth versus time plot for an individual hook.



The movement of the hook whilst it is at the fishing depth is likely to be due to currents, whilst the rapid decrease and increase in depth while the hook was being hauled may be due to a short delay in the hauling process (possibly due to processing the catch) during which time the hook descended again.

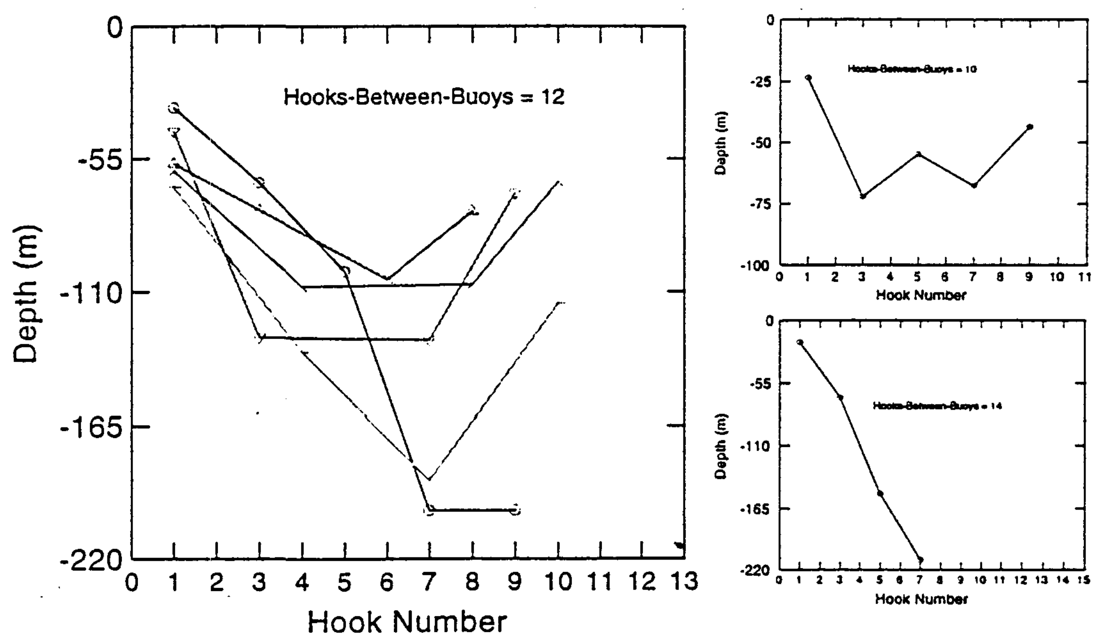
A number of technical problems with the monitors prevented the successful retrieval of much of the data during the winter survey. Therefore, the results presented in this section relate only to the data collected during the spring survey.

5.2 Mainline Shape between Buoys

Under gravity alone, a longline is assumed to take up a catenary configuration between any two buoys. However, the play of the currents on the gear, the buoyant nature of the lighter monofilament line, together with other factors will act to distort the line from this classical shape. In order to investigate the shape of the line between buoys, hook monitors were placed on a number of hooks between two buoys. The section of line between two buoys is often referred to as a basket, owing to the historical practice of the Japanese in storing this section of the line in a wicker basket.

In Figure 10 below, the individual depths of hooks within a single basket with 12 hooks

Figure 10. Average depths of hooks versus Hook position for different configurations.



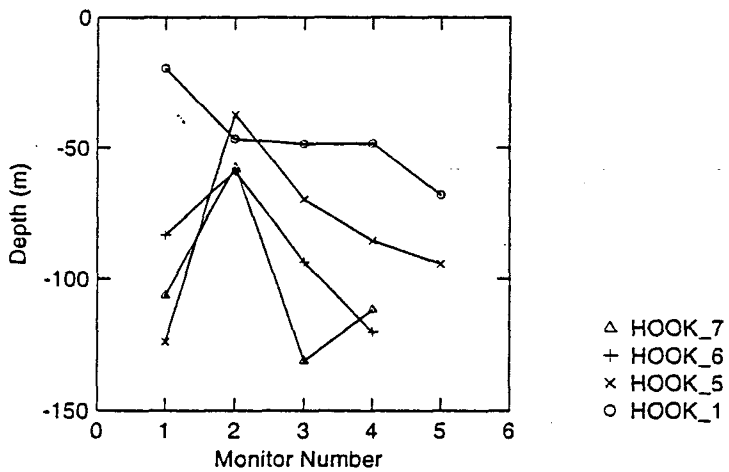
between buoys are shown. The results for five separate baskets on five different sets are shown. In general, a pattern of increasing depth with hook number is found, with the deepest hook being found at positions 6 or 7 in all cases. This result corresponds to that expected from a line hanging symmetrically between the buoys. However, as can be seen, some hooks have similar depths at positions 3 and 7 in one basket and positions 7 and 9 in another basket, indicating that the symmetry of the hanging line cannot always be assumed. Furthermore, there is large variation in the depth of hooks at any particular hook position indicating that the depth configuration of the line may vary considerably between sets.

The two smaller figures on the right give single observations for baskets with 10 and 14 hooks between buoys. While the configuration of the mainline in the top figure is approximately symmetric, the depth of the middle hook (position 5) is found to be less than the hooks on either side. This observation, together with some of the observations in the previous figures, indicates that in some instances the configuration of the deeper hooks may be somewhat flat with the depth of hooks being distributed around some average depth. This configuration may be due to the fact that the monofilament line being used is light and somewhat neutrally buoyant making the ultimate configuration of the line quite susceptible to ocean currents. Nevertheless, as can be seen from the three figures above, there is a general trend for the central hooks to fish deeper when there are more hooks between buoys.

5.3 Consistency of Depths Along Mainline

During some sets the depth monitors were placed on hooks with similar hook numbers, ie they were placed on hooks with the same hook position between different buoys (within different baskets). This was done in order to evaluate the similarity of depths reached by similarly positioned hooks but at different positions along the mainline. The results of monitoring hooks having positions 1, 5, 6 or 7 are shown in the Figure 11 below.

Figure 11 Depth of hooks along the mainline.



For the monitors at hook position 1, three are seen to have similar behaviour, with average fishing depths between 45-50 metres. However, the average depths fished by the other two hooks are different, with one fishing at around 20 metres and the other at around 70 metres. For each of the other hook positions, the average depths on the monitors display greater variation.

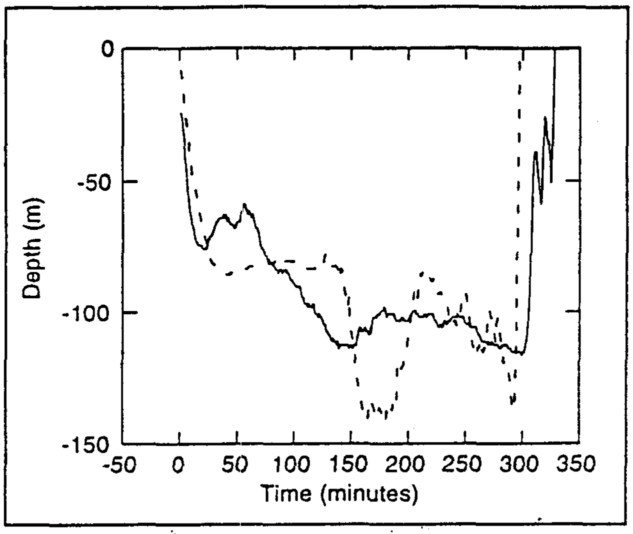
This result indicates that hooks with similar positions between buoys do not necessarily have similar fishing depths along the same line. Hence, monitoring of the depths fished by one portion of the longline cannot necessarily be extrapolated to the depths by all portions of the longline. This observation extends to a single longline the result found in the previous section where the shape of the line within individual baskets was found to be different between lines. Unfortunately, due to the non-uniform manner in which the line was deployed, it remains unknown how much of this variation is due to differences in the rigging of the line within individual baskets and how much is due to variation in the settled configuration of identically rigged baskets.

5.4 Consistency of Depth With Time

The depth-versus-time figure shown in section 5.1 indicates a high degree of stability in the depth of the hook during the soak time of the set. However, such stability was not always observed. Indeed, the depth of a hook often varied considerably during a set.

Two instances of such behaviour are shown in Figure 12 below. For the set indicated by the solid line, the hook first settles at a depth of around 75 metres. After initially rising, the hook then slowly descended to a depth of around 110 metres where it remained until hauled. For the other set shown, the hook settled out at around 85 metres but after 130 minutes rapidly descended to around 140 metres then ascended back to 85 metres before eventually descending back to around 130 metres just prior to being hauled.

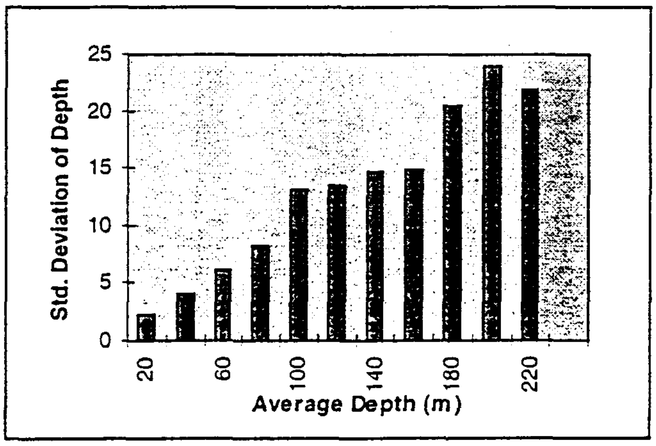
Figure 12 Depths versus time for two hooks.



The reasons for such behaviour remain unclear but are likely due to the vertical movement of fish caught on nearby hooks and /or the response of the line to variations in the local currents. While individual hooks will drift up and down in response to currents, over time these same currents will alter the configuration of the mainline itself. For example, as two buoys drift closer together in response to the interplay of the tension in the gear and the local currents, the line (and associated hooks) between the buoys will attain a greater depth. This may explain the common observation for the hooks to slowly descend during the period of the soak. This is seen in the time-series shown in the lower figure on the previous page.

Because the mainline is secured to buoy lines, which remain fixed in length during a set, any variation in the depth of the line will be greatest at the lowest point. Therefore, one would expect to see greater variability in depth of a hook as the depth increases. For each hook monitored the mean and standard deviation of the observed depths were calculated. The average of the measured standard deviations, stratified by mean depth, are plotted in Figure 13 on the right. An almost linear increase is found with increasing depth. This result indicates that the variation in hook depths during a set increases with the average depth attained by a hook. While this result is expected in light of the comment above, this variability may also be due to a number of others factors, such as changes in current strength with depth, possibly in relation to a thermocline if present.

Figure 13 Standard deviation of hook depth vs. average depth



5.5 Depth versus Hook Number

The above results indicate that there were a range of depths associated with any given hook position. Combining the results from all sets, the depths obtained against hook position are shown in the Table 4. For each hook position the following depths are shown:

- the mean and standard deviation of the average fishing depths for each set (column plus vertical line),
- the minimum and maximum of the average fishing depths for each set (up and down arrow),
- the minimum and maximum fishing depths obtained during any set (horizontal lines).

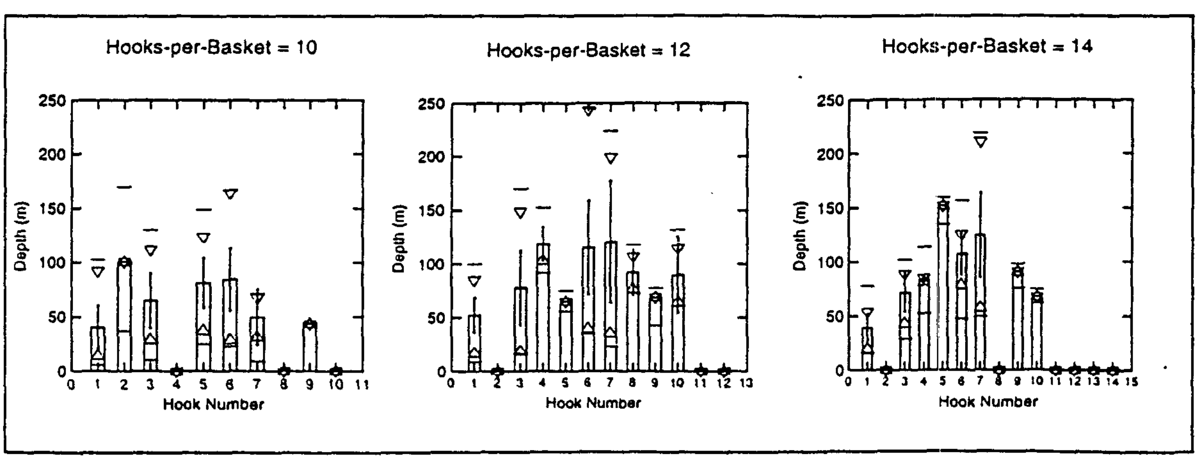
The results are grouped by the number of hooks-per-basket and displayed in the three plots given in Figure 14 below. Note the symbols used to display each statistic in these figures are

Table 4. Statistics of observed fishing depths of hooks versus hook position.

Hooks -per-Basket	Hook Number	Number of sets	Mean Depth of Average for each Set	Standard Deviation of Mean	Minimum Average Depth	Maximum Average Depth	Minimum Depth of any Set	Maximum Depth of any Set
10	1	17	40.4	20.1	14.0	92.3	6.0	103.0
	2	1	100.8	.0	100.8	100.8	37.0	170.0
	3	14	64.9	25.4	29.1	112.1	10.0	130.0
	5	14	81.1	23.2	37.3	124.0	25.0	149.0
	6	22	84.4	29.1	28.9	164.5	23.0	167.0
	7	2	49.7	25.7	31.5	67.8	9.0	72.0
	9	1	43.6	.0	43.6	43.6	41.0	45.0
12	1	24	52.6	16.5	16.9	85.3	9.0	100.0
	3	15	78.1	34.7	18.5	149.1	17.0	170.0
	4	4	118.7	15.6	103.1	134.8	92.0	153.0
	5	1	65.0	.0	65.0	65.0	56.0	75.0
	6	37	115.4	43.8	39.6	243.6	35.0	245.0
	7	8	120.6	56.8	35.6	199.6	23.0	224.0
	8	2	91.9	21.4	76.8	107.0	73.0	118.0
	9	1	69.2	.0	69.2	69.2	43.0	78.0
	10	2	89.8	35.4	64.7	114.8	61.0	132.0
14	1	8	39.4	13.0	19.4	54.1	16.0	78.0
	3	5	71.8	17.7	43.1	89.0	29.0	102.0
	4	2	83.5	2.6	81.6	85.3	53.0	114.0
	5	1	152.0	.0	152.0	152.0	135.0	160.0
	6	6	107.2	18.9	78.7	125.7	48.0	157.0
	7	10	124.5	39.1	57.5	211.2	50.0	219.0
	9	1	90.8	.0	90.8	90.8	76.0	98.0
	10	1	67.8	.0	67.8	67.8	62.0	75.0
15	3	1	122.6	.0	122.6	122.6	105.0	157.0
	4	1	200.1	.0	200.1	200.1	163.0	216.0
	8	1	248.3	.0	248.3	248.3	201.0	308.0
18	9	3	94.2	5.6	87.8	97.5	65.0	143.0
20	10	2	210.5	19.2	196.9	224.1	106.0	287.0
25	1	1	50.4	.0	50.4	50.4	37.0	93.0
	13	1	192.9	.0	192.9	192.9	163.0	231.0

listed in the parentheses above. As noted with previous results, the depths associated with each hook position are found to vary over a considerable range. For example, the average of the depths fished during any single set by a hook at position 5 with 10 hooks-per-basket ranged from 37.3 metres during one set to 124.0 metres in another set. The mean of these average depths for the 14 observations for this hook position was 81.1 metres, though the

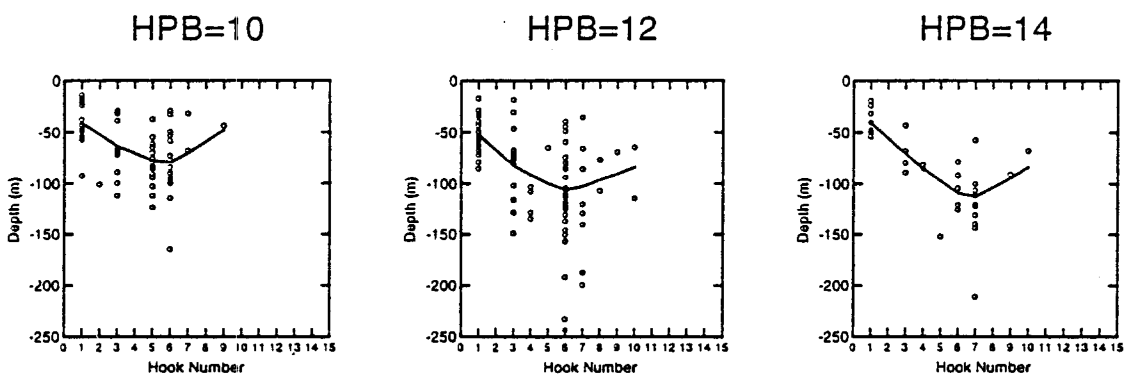
Figure 14. Statistics of observed fishing depths of hooks versus hook position.



minimum and maximum depths obtained by a hook at this position ranged from 25 to 149 metres.

While there is great variation between sets, the average depths shown in the Figure 14 do nevertheless display a regular pattern. For example, if one ignores the results where there is only a single observation, it is seen that in all but one instance (position 4 > position 5 for 12 hooks-per-basket, but only just) the average depth fished increases with hook-position until either of the central positions is reached. Although the data is more sparse, a corresponding decrease after the central positions is also seen. These results indicate that, on average, there is a general pattern in the depths fished by the hooks within any basket, a pattern which would approximate the caternary expected. This can be seen more clearly in the three configuration shown in Figure 15 below where a curve of best fit (LOWESS with tension=0.75) has been fitted to the plots of the average depth versus hook position for each monitored hook position (shown as dots). Again, the deepest hooks in each configuration are associated with the central hook positions within each basket. However, instead of the line having the rounded shape expected of a catenary between the buoys, the depth is seen to increase in a more linear fashion between the shallowest and deepest hooks.

Figure 15. Best-fit curves showing average depth fished versus hook position.



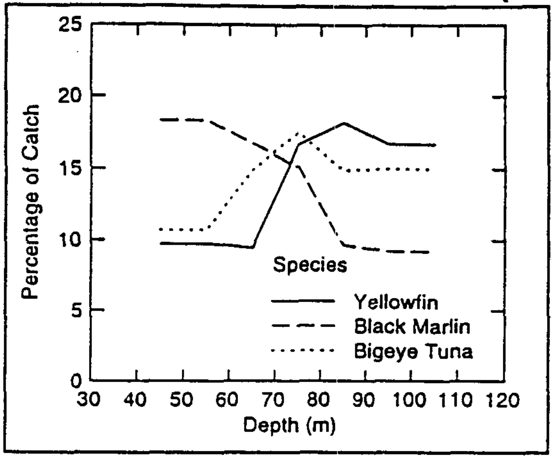
Finally, the practice of increasing the number of hooks placed between buoys (within a basket) to target a greater range of depths can be investigated. In Figure 15 the depth fished by the deepest hook, and the corresponding range of depths fished between the buoys, is seen to increase as the number of hooks-per-basket increases. This result is expected and confirms the use of changing the configuration of the longline in order to target greater depths. However, while the difference in depths attained by the deepest hooks for lines with 10 and 12 hooks-per-basket is around 25 metres, the difference for lines with 12 and 14 hook-per-basket is only around 10 metres. This asymmetry may be due to differences in the length of the buoy lines associated with sets deploying different line configurations.

5.6 Vertical Distribution of Tunas and Billfish

By combining the distribution of catch by hook position for the principal catch species with the average depths attained by hooks at each position reported above, some indication of the average distribution of the these species with depth was obtained. This distribution was expressed as the percentage of the catch within each 10 metre depth strata. The results for the three principal species caught are shown in the Figure 16.

From this figure it is seen that black marlin are generally caught by hooks at depths less than 80 metres, while the two tuna species are caught by hooks at depths greater than about 70 metres. Using the depth of capture as an index of abundance, it is seen that while the distribution of black marlin and the target tuna species overlap, there is a level of vertical stratification of the depths at which these two species groups are most abundant.

Figure 16. Catch distribution versus hook depth.



While the above calculations are based on a number of assumptions (eg. fish not caught while hook is being set or hauled) and have used the averages of fairly 'noisy' data, the general conclusion that black marlin inhibits shallower depths than yellowfin and bigeye tunas is not unexpected and corresponds with the observations from similar work carried out elsewhere. For example, Suzuki (1977) reports that the catch rates of black marlin by deep longlines is about one-third that for regular longlines. More recently, Nishi (1990) found that for regular longlines, the proportion of billfish, yellowfin and bigeye tuna found on the shallowest hooks was 59, 24 and 26 percent respectively, while the corresponding proportions on the deepest hooks were 14, 27 and 33 percent.

5.7 Hook-Depth versus Time Profiles

For each observed hook, a histogram of hook-depth versus time was ascertained. Collation of this information across all observed hooks was then undertaken to ascertain a depth versus time profile of all hooks deployed on the observed vessels. Since only a small sample of hooks were observed, a number of corrections were necessary to ensure an adequate representation of all hooks deployed. First, the observations for each hook position and hook-per-basket configuration were pro-rated to ensure an even coverage of observations across all hook positions. Secondly, the observations for each hook-per-basket configuration were also pro-rated to ensure that each configuration was represented in the same proportion of those observed across all sets. The resulting histogram of hook-depth versus percent of total soak time is given for both surveys in Figure 17 below.

Figure 17. Histogram of depth attained by hooks versus percentage of soak time.

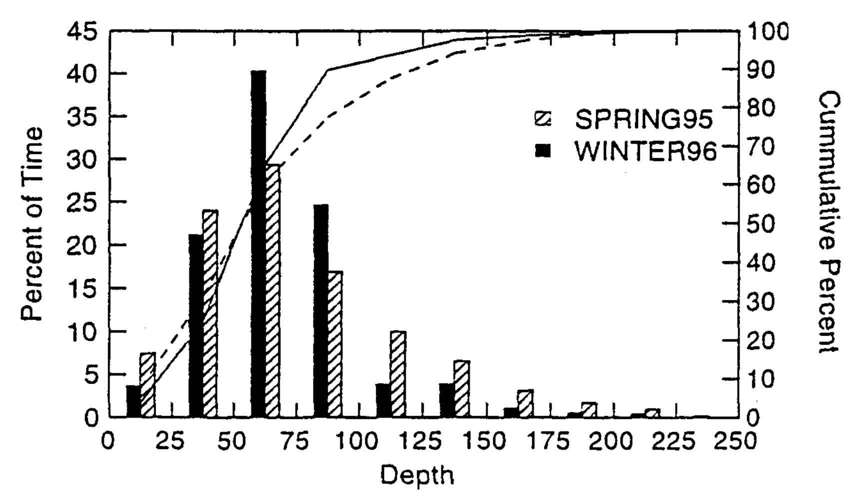


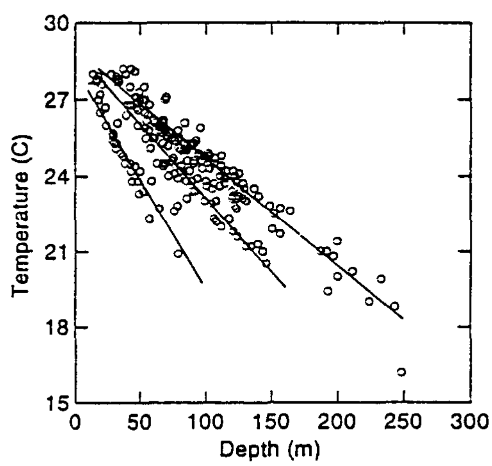
Figure 17 gives the percentage of the total deployment time (the time between setting and retrieval of hooks) that hooks were observed to spend in each 25 metre depth strata. For example, the most common depths fished by the hooks are seen to be between 50 and 75 metres, accounting for just under thirty percent of the total hook deployment time. The solid line in the same figure gives the cumulative percentage of total time which hooks spend above given depths. From this result, it is seen that the time spent by hooks in the upper 100 metres of the water column accounts for about 80 percent of the total hook deployment time. Consequently, hooks spend less than a quarter of the total time deeper than 100 metres (and only around 5 percent of the time deeper than 150 metres).

Given the results of the previous section indicating that the target tuna species have greater abundance at depths greater than 80 metres, it would be desirable for the longliners to configure their gear so that the time hooks fish at depths greater than 80 metres is maximised. Whilst this would help target the hooks to the depth stratum preferred by the target tuna species, it would have the added benefit of minimising the amount of time hooks fish at those depths which seem to be preferred by black marlin. This would help to minimise the by-catch of this species.

5.8 Temperature versus Depth

As well as depth data, the hook monitors also recorded water temperature. A plot of the average temperature recorded for each monitored hook against the average soak depth of the hook (spring survey only) is shown in the Figure 18 on the right. While there is a scatter of temperatures associated with any depth, the relationship between the two variables is seen to be roughly linear. Of interest is the fact that at least three such relationships can be inferred from the data (shown by the lines) and are possibly due to temperature-depth relations within three different water bodies. Changes in the temperature with depth are expected as the season progresses due to the southwards movement of warmer water associated with the onset of summer (Hisada, 1973).

Figure 18. Water temperature versus depth



6: Hook Timer Information

6.1 Deployment of Timers

Hook timers were attached near the top of selected branch-lines. A fish striking the hook below results in the branch-line pulling the sheath (containing the magnet) off the timing unit. This starts the clock which begins to record the elapsed time since the strike. The elapsed time is then read when the branch-line is recovered. Hook timers were distributed fairly randomly along the length of the mainline which should have ensured a fairly random distribution of timers with depth.

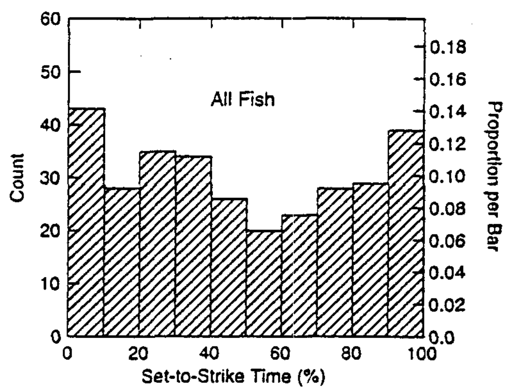
During the first survey, hook timers were attached to 2,217 branch-lines of which 316 (14%) had been triggered upon retrieval. However, less than half of the triggered timers (145 or 46%) had a retained catch upon retrieval. During the second survey, hooks timers were attached to 1,743 branch-lines of which 201 (12%) had been triggered upon retrieval. Again, less than half (80 or 40%) had an associated catch. The duration of time between the time a hook is set (set time) and the time when a fish strikes the bait and triggers the timer (strike time) is called the set-to-strike time, whilst the time between the strike time and retrieval time of the hook (haul time) is called the strike-to-haul time. Note: there was no significant difference in catch rates (65.9 versus 67.6) between hooks with and without monitors attached.

6.2 Distributions of Strike-Times

Since sets were of different duration, the distribution of set-to-strike times are not easily comparable between sets. Instead, in the following analysis this time is expressed as the percentage of the total deployment time for that hook. For example, consider a hook which is deployed at noon and retrieved at 5pm. If the hook timer shows a time of 2.0 hours upon retrieval then a strike on that hook took place at 3pm and the set-to-strike time for that hook accounts for three of the five hours, or 60 percent, of the total soak time.

The distribution of set-to-strike percentages for all the triggered hook timers retrieved during the first survey is shown in Figure 19 on the right. The highest occurrence of strikes is seen to be at the start and end of the sets, and, except for the second decile, there is a relatively smooth decrease in strikes towards the midpoint of the set followed by a smooth increase in strikes towards the end of the set. A chi-squared test indicates that this distribution of strike times is significantly different from a constant distribution ($p<0.10$).

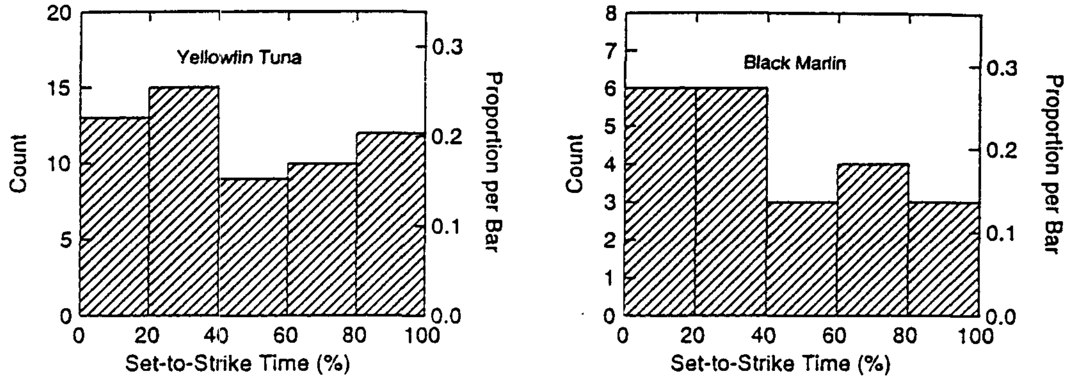
Figure 19. Distribution of strike times



A number of factors may contribute to the initial decrease in strike times as time increases. For example, the effectiveness of the bait will decrease with time due to bait loss and a decrease in the leaching of attractive proteins into the water column. However, this fact will not explain the subsequent increase in strikes towards the end of the set. It is possible then that the strike rates are increased during the setting and hauling processes. Such increases may be due to movement of the hooks (and the baits) through the water providing a more observable target for the fish caught combined with a possible higher abundance of non-targeted species in the upper water column. On the other hand, the higher instances of 'strikes' at the start and end of above distribution may have also been due to the accidental triggering of some timers during the setting and hauling process. Note that no difference in the distribution of strike times was observed in the data collected during the second survey.

The distribution of set-to-strike times can also be investigated for individual species. For example, the distribution of such times for the 59 yellowfin tuna retained on hooks with hook-timers is shown in Figure 20 below. Unlike the previous result for all strikes, a chi-squared test supports the hypothesis of an even distribution in the occurrence of strikes for the yellowfin tuna caught on hook-timers. The distribution of set-to-strike times for black marlin is shown in the figure on the right. Whilst there would appear to be a greater tendency for black marlin to strike during the first half of the set, the small samples in each of the categories (3-6 fish) precludes any significance in this trend ($p>0.20$). The lack of evidence for yellowfin tuna to be caught preferentially during the settling or hauling of the hooks, and the fact that this species is generally deeper in the water column than many of the other species caught, supports the notion that the higher strike rates early and late in the set are due to the catch of species which occur in the upper layers of the water column. Furthermore, the

Figure 20. Distribution of strike-times for yellowfin tuna and black marlin.



observation that black marlin generally occur in the upper water column and may be attracted to the line by tuna already caught, one may expect an increase in strikes by this species as the line is being hauled. However, more observations are needed to clarify this point.

6.3 Strike Time versus Time-of-the-Day

As well as investigating the distribution of strike times within a set, the distribution of strike times according to the time of the day is of more interest. The number of timers triggered in each two hour period of the day (midnight-2am, 2am-4am,...,10pm-midnight) is given in Figure 20a on the right. However, since the number of hook-timers in the water is not the same for each time period one cannot use this distribution as an indicator of total strike-rate versus time-of-the-day. For example, the number of timers triggered will be proportional to the number in the water at any time, not just the number of fish taking baits.

Figure 20a Distribution of strike-times

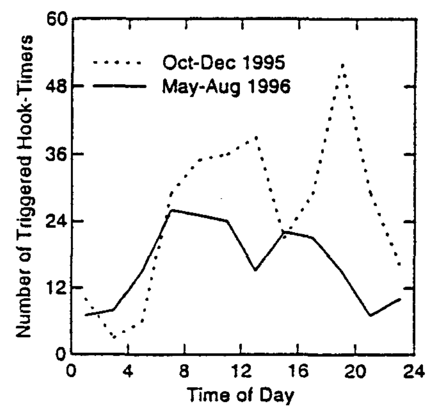
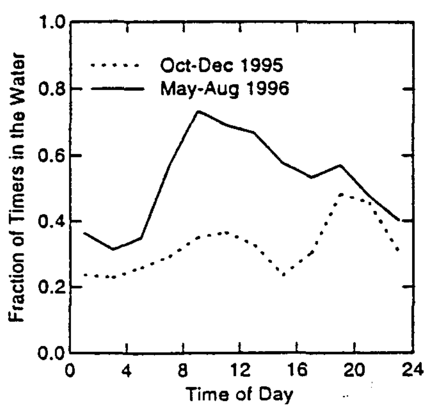


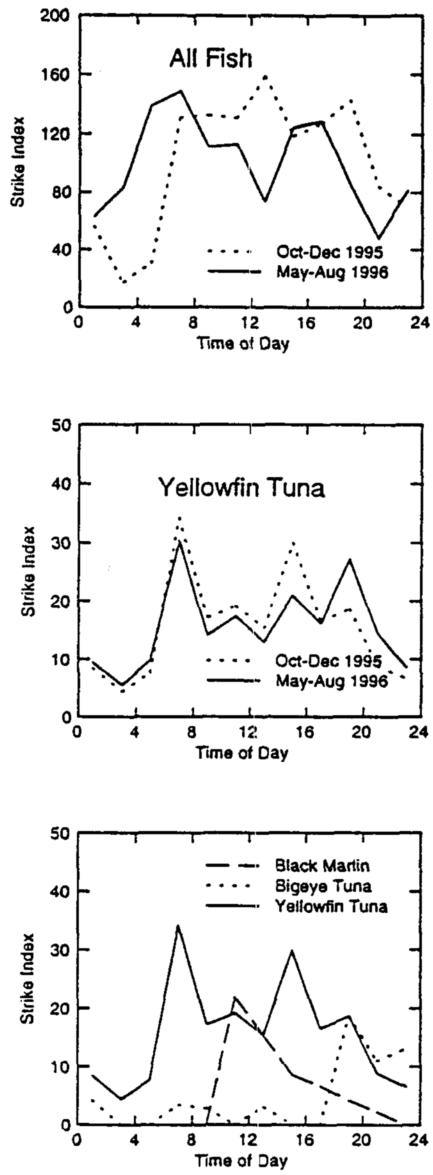
Figure20b Distribution of timer soak times



In order to overcome this problem the fraction of each two hour period each triggered hook-timer was in the water was calculated. These fractions were averaged for all timers and the distribution of the these averaged fractions is given in Figure 20b on the lower right. For example, the result of 0.40 at 2300 hours for the winter survey means that, on average, between 2200 hours and midnight only 40 percent of the 201 timers which were triggered during this survey were in the water during this period. Dividing the number of timers triggered in each period by the corresponding fraction of timers in the water will give an index of hook strikes for each period. Note, this index should be based on the distribution of the total number of hook-timers in the water during each period, not just the distribution of triggered timers. Instead we assume that the triggered timers are a random sample from the total number of timers so that the distributions of timers in each period are similar.

The calculated index for all timers (ie all fish strikes) is shown in the upper plot of Figure 21 on the right. The indices associated with a catch of yellowfin tuna for each survey are given in the middle plot, while the indices for bigeye tuna and black marlin obtained from the spring survey only are shown in the lower plot.

Figure 21 Strike-index vs. Time-of-day



The index for all fish indicates that the strike rate is seen to be low in the late evening and early morning, with relative maximums around mid morning and mid-afternoon. The pattern of strike rates during the day is seen to be similar for the two seasons, though the increase in the morning and the decrease in the evening occur about two hours earlier in the winter. This difference is possibly related to differences in the times of sunrise and sunset during the two surveys. The relative high valve of the index around noon in the spring survey is due the high strike rate of black marlin at this time, and the absence of black marlin in the second survey may help explain the lower index around this time.

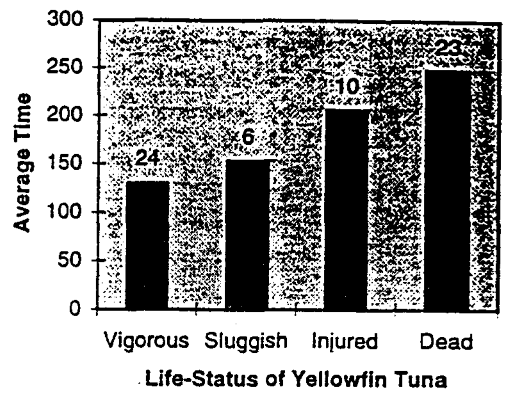
The two indices for yellowfin tuna are also quite similar, with both indicating a minimum strike rate early in the morning with a relative maximum around mid-morning (6-8am). However, while both indicate a second relative maximum, the timings are slightly different with the winter survey being in the early evening whilst the spring survey in mid-afternoon. Whilst the sample sizes for these observations are not large, being only 25 fish for the winter survey and 60 fish for the spring survey, the general similarity of the results reinforces the general conclusions drawn from these observations.

For bigeye tunas, the strike rate during the spring months is low during the day and increases in the late evening. This may be related to the successful targeting of aggregations around the full moon when these fish are generally closer to the surface. Finally, the index for black marlin is seen to be zero between midnight and 8am after which time it increases to a peak around midday before decreasing during the rest of the day. While the lack of strikes before 8am coincides with a period of inactivity observed in black marlin tracked by acoustic telemetry (Pepperell and Davis, 1996), observations from the charter boat fleet indicate that strike rates generally remain high throughout the afternoon (Pepperell, pers. comm.), unlike the decline seen in the data above.

6.4 Life-Status

Knowing the strike-to-haul time and the resulting life-status of the catch upon retrieval, it is possible to determine the relationship between these two variables. For yellowfin tuna caught during the spring survey, the average strike-to-haul time was calculated for each of the four life-status categories. The results are shown in Figure 22 below where the number above each column gives the sample size. A strong relation is seen between length of time a fish spends on the hook and the probability of it being dead on retrieval. Most fish remain in a vigorous state after two hours on the hook but after 4 hours most are observed to be dead.

Figure 22. Hooked Time vs. Life-status



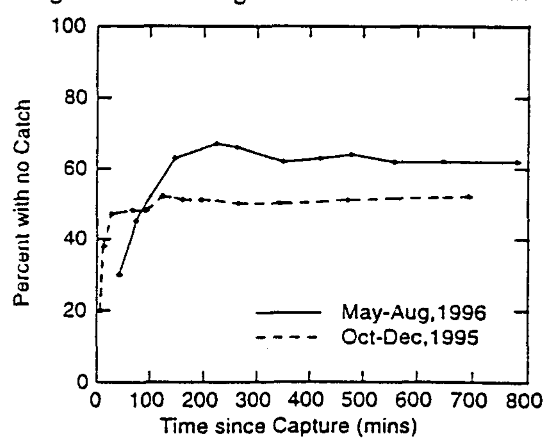
6.5 Loss of Hooked Fish

It was noted earlier that less then half of the hook-timers which were observed to have been triggered during each survey had an associated catch when the hook was retrieved. Whilst it is possible that timers were accidentally triggered during the process of the line being set and retrieved the occurrence of this appears to have been small. Evidence for this is seen in the lack of timers registering a set-to-strike time of either zero or 100 percent of the total soak time.

Two other possibilities, however, may explain the high occurrence of empty hooks. First, it is possible that some fish manage to take the bait, and trigger the timer, without actually being caught. Second, some fish may take the bait, get hooked, but then manage to escape from the hook before the line is hauled. If the fraction of fish taking a bait but not being hooked is relatively constant with time, then the percentage of triggered timers with a catch should remain constant over time. On the other hand, if fish first get hooked then manage to escape then the percentage of triggered timer with no catch should increase with time.

In order to investigate the likelihood of these possibilities, the percentage of timers with no catch upon retrieval was plotted against the elapsed time since the timer was triggered. The result is shown in Figure 23 on the right. Note that each data point is based on a sample of twenty timers, except for the first which is based on a sample of size ten. The analysis is also not species specific. For comparison the result for each survey are shown.

Figure 23 Percentage of timers with no catch.



For the winter survey, the percentage of triggered hooks with no catch is seen to increase during the first 3 hours after which time it remains relatively constant at around 60 percent. This may indicate that fish first get caught then manage to escape at some time up to three hours after being hooked. Because the analysis could not be extended back to a few minutes after the timer was triggered, it is also possible that some fish manage to take the bait (and trigger the timer) without being hooked, but the likelihood of this is probably less than 20 percent. While a study of the stomach contents of 89 bigeye and yellowfin tunas (Yamaguchi and Kobayashi, 1974) found evidence for fish taking more than one bait, the occurrence of such events was not high, with two or more baits found in only five of the fish sampled. Of more interest was the fact that 36 (40 percent) of the fish sampled had no bait in their stomachs. This indicated the possibility of a high instance of regurgitation of baits and it was further suggested that many fish escape being hooked by regurgitating the hook and the bait.

Finally, observations of the movement of hooks with attached depth monitors indicates that the average survival times of tunas after being hooked is around 1.5 hours for yellowfin tuna and 3 hours for bigeye tuna (Yamaguchi, 1989). These results seem to concur with the result above which indicates the possibility that fish continue to escape from the hook up until around three hours after becoming hooked. For the spring survey, this time appears to be appreciably shorter. Reasons for this remain unclear but may be due to the warmer water temperatures at the time of the spring survey (around 3°C higher than the winter survey). Warmer ambient temperatures may exhaust a struggling fish more quickly resulting in a quicker death. This would also explain the fact that a higher proportion of the catch remains hooked (around 50 percent). In conclusion, if one assumes that a high proportion of the timers which were triggered coincided with the hooking of a fish, then the high proportion of empty hooks upon retrieval would indicate quite a high loss rate of hooked fish. The loss of hooked fish in this manner also helps explain the decrease in catch-per-hour noted earlier with sets of long duration (cf. Section 4.3)

7. Discussion

This paper summaries the data, and the some of the conclusions inferred from this data, collected during two observer based surveys of the fishing operations and catch by domestic longline vessels fishing off north-eastern Queensland. These surveys were the first time such a detailed examination of domestic longline vessels operating within Australian waters had been undertaken, despite the presence of observers on board Japanese longliners operating within the AFZ since 1980. A fuller description of the data collected and discussion of the results of these surveys can be obtained by requesting copies of the following two reports:

1. Domestic Longline Fishing Methods and the Catch of Tunas and Non-target species off North-eastern Queensland (1st Survey: October-December, 1995)
2. Domestic Longline Fishing Methods and the Catch of Tunas and Non-target species off North-eastern Queensland (2nd Survey: May-August, 1996)

from

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Appendix A: Listing of the total catch details.

1. Spring Survey

Table A1. Listing of Observed Catches.

Common Name	Number Caught	Retained or Finned	Not Retained	Unknown Fate
Yellowfin Tuna	538	429	99	10
Bigeye Tuna	246	167	78	1
Black Marlin	216		212	4
Sharks (Commercial catch)	60	47	11	2
Thintail Thresher Shark	38	13	24	1
Oceanic White Tipped shark	37	33	3	1
Escolar or Black Oil fish	34	25	9	
Barracouta	33		32	1
Long Nosed Lancet Fish	30		29	1
Rudderfish	29	22	6	1
Dusky Shark	26	25		1
Short Nosed Lancet Fish	26		25	1
Skipjack Tuna	25	19	6	
Albacore	23	21	2	
Blue Whaler Shark	16	16		
Dolphin Fish	16	15	1	
Wahoo	16	14	1	1
Oilfish	12	11	1	
Slender Barracuda	12		12	
Silky Shark	8	7		1
Unknown	6		4	2
Broadbill Swordfish	3		3	
Sandbar Shark	3	3		
Crocodile Shark	2		1	1
Tiger shark	2	2		
Shortfinned Mako	2	1	1	
Longfinned Mako	2	2		
Blue Marlin	1		1	
Opah or Moonfish	1	1		
Thresher Shark	1		1	
Turtle	1		1	
Bluefin Tuna	1		1	
Hammerhead Shark	1	1		
All Species	1,467	875	564	93

2. Winter Survey

Table A2. Listing of Total Catch by Species.

Common Name	Number Caught	Retained or Finned	Not Retained	Unknown Fate
Yellowfin Tuna	451	414	37	
Albacore Tuna	140	137	1	2
Long-nosed Lancet Fish	124	1	123	
Barracouta	93		93	
Bigeye Tuna	85	77	6	2
Escolar or Black Oil Fish	58	32	26	
Dolphin Fish	45	36	8	1
Skipjack Tuna	40	12	26	2
Dusky Shark	39	19	20	
Broadbill Swordfish	37	9	27	1
Wahoo	37	33	4	
Oilfish	13	4	8	1
Silky Shark	11	6	5	
Blue Whaler Shark	9	3	6	
Unknown	8		7	1
Tiger Shark	6	4	1	1
Thresher Shark	4	1	3	
Great Barrcouta	3		3	
Shortfinned Mako	3	3		
Oceanic White Tipped Shark	3	2	2	
Opah or Moonfish	2	2		
Pelagic Ray	2		2	
Short Bill Spearfish	2		1	1
Striped Marlin	2		2	
Sharks (commercial)	2			2
Rainbow Runner	2	2		
Short Sunfish	1		1	
Dog Shark	1	1		
Manta ray	1		1	
Whale	1		1	
Gemfish or Couta	1		1	
Hammerhead Shark	1	1		
Long Finned Bream	1		1	
All Species	1,228	799	415	14