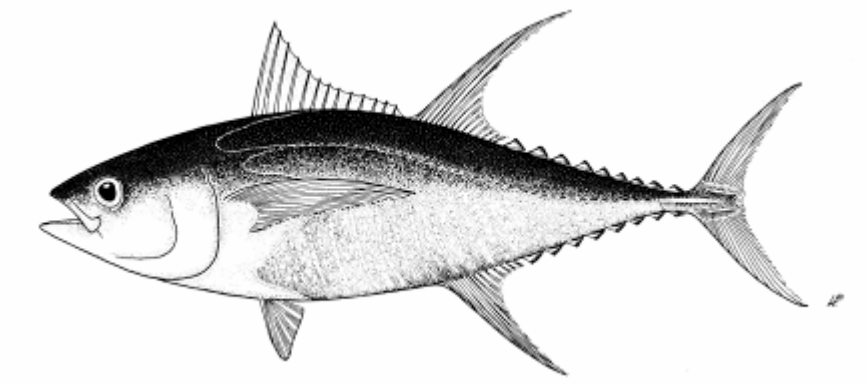
WCPFC–SC1 **EB WP–9**

Western and Central Pacific Fisheries Commission

1st Meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission
WCPFC–SC1
Noumea, New Caledonia
8–19 August 2005

Byproduct: catch, economics and co-occurrence in the Australia's Eastern Tuna and Billfish longline fishery



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August 2005

Byproduct: Catch, Economics and Co-occurrence in Australia's Pelagic Longline Fisheries

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Abstract

The domestic longline fishery operating off the east coast of Australia incidentally takes over 80 non-target species. A significant amount of this non-target catch is retained as byproduct. Total retained byproduct increased through the 1990s to peak at just over 1300 mt (19.6% of total retained catch) in 2002. Due to the difficult economic outlook faced by these fisheries (resulting from overcapacity, localised depletions, increased fuel prices, lowered availability of target species and reduced access to export markets) byproduct has become a relatively more important part of some fishers' catch and income. This paper summarises a recent review of the catch and economics pertaining to 19 key byproduct species taken in the domestic longline fishery, and identifies both opportunities and threats for sustainable fisheries management associated with these trends. A comparative analysis of observer and logbook data suggested under-reporting of catches and discarding for a significant number of these species. There are five key byproduct species, these being albacore tuna (*Thunnus alalunga*), shortfin mako shark (*Isurus oxyrinchus*), dolphinfish (*Coryphaena hippurus*), rudderfish (*Centrolophus niger*) and black oilfish (*Lepidocybium flavobrunneum*) which comprise over 90% of the total catch and value of byproduct. With the exception of albacore tuna, the status of most byproduct species is unknown, but with falling catch rates in recent years and significant retention rates, some concern is held for the status of pelagic shark species such as blue shark and shortfin mako. On the other hand, albacore tuna may offer some opportunity for further fishery development.

Introduction

The longline sector of the eastern Australian tuna and billfish fishery targets 4 main species (yellowfin tuna, *Thunnus albacares*; bigeye tuna, *Thunnus obesus*; broadbill swordfish, *Xiphias gladius*; and striped marlin, *Tetrapturus audax*) and incidentally take over 80 other species. While much of this non-target bycatch is discarded, a significant number of these species will often be retained for sale, and are referred to as byproduct. Total retained byproduct increased through the 1990s to peak at just over 1300 mt (19.6% of total catch) in this fishery in 2002.

Historically, byproduct species have received relatively little management attention in Australia because they had low value, were not targeted, and there was little validated data available for the provision of scientific and economic advice pertaining to these species. In recent years however, retained catches of numerous byproduct species have increased significantly and data collection systems, including improved logbooks and observer programs, have been put in place. Furthermore, as economic pressures in the fisheries increase, fishers have been calling for increased access to byproduct (e.g. dolphinfish and shark fin being recent examples). Aside from these pressures on managers, there is also a clear requirement for the consideration of these species in management procedures and policy making that flows from the Fisheries Management Act (1991) and the Commonwealth Bycatch Policy (2000).

This paper provides an overview of a recent report (Bromhead et al. 2005) that was commissioned to provide information regarding the catch, value and co-occurrence of byproduct species in Australias domestic longline fisheries. More specifically the purpose of the report was to assess the reliability of logbook data for providing information upon which to base management decisions, determine spatial and temporal trends in catches for each species, assess the economic value of byproduct, and examine patterns in co-occurrence of byproduct species with target species. It uses this information as a base to identify both the opportunities and threats to sustainable fisheries management that are presented by increasing retention and catches of byproduct species.

Based on preliminary indicators of total catch and economic value, 19 byproduct species (or species groups) were chosen for review. They are albacore tuna (*Thunnus alalunga*), ray's bream (*Brama brama*), dolphinfish (*Coryphaena hippurus*), rudderfish (*Centrolophus niger*), shortfin mako shark (*Isurus oxyrinchus*), blue shark (*Prionace glauca*), bronze whaler shark (*Carcharhinus brachyurus*), oceanic whitetip shark (*Carcharhinus longimanus*), scalloped hammerhead shark (*Sphyrna lewini*), wahoo (*Acanthocybium solandri*), tiger shark (*Galeocerdo cuvier*), shortbill spearfish (*Tetrapturus angustirostris*), black oilfish (*Lepidocybium flavobrunneum*), oilfish (*Ruvettus pretiosus*), moonfish (opah)(*Lampris guttatus & L. immaculatus*), blacktip shark(s)(*Carcharhinus tilstoni, Carcharhinus limbatus*), northern bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Katsuwonus pelamis*), and porbeagle shark (*Lamna nasus*). Data for these species were contrasted against those of the four target species.

Data sources

The data types used in this project, along with the data sources, are summarised in Table 1.

Table 1 – Sources and types of data used.

Data group	Data type	Source(s) of data
Catch/Effort	Domestic logbook	Australian Fisheries Management Authority (AFMA)
	Japanese logbook	AFMA
Observer	Domestic observer program	AFMA
	Japanese observer program	AFMA
Economic	Domestic Processor data	ABARE
		Seafood Processors*
	Market data	Sydney Fish Market
		Victorian Government – Melbourne Wholesale Fish Market
	Export data	Australian Bureau of Agricultural and Resource Economics
		Australian Bureau of Statistics
		Seafood Processors*

Note: * Processor names are kept confidential.

Analysis of logbook data reliability

The reliability of domestic longline logbook data was reviewed as the projects first task. A number of limitations effect logbook catch data prior to 1997, including low logbook coverage (Anon. 2002), reduced fisher education with respect to filling out logbooks, and a low number of byproduct species listed. Consequently, key data summaries and analyses relied on data post-1997. A reporting error was also discovered in the logbooks, whereby some fishers appear to have accidentally recorded discards in the retained catch field. Where identifiable, these records were removed from the database.

In addition, a comparative analysis of observer and logbook data was undertaken to assess the accuracy of logbook reporting. Due to the relatively “patchy” spatial and temporal nature of observer coverage in this fishery, analyses were focused on data from within discrete times and areas where observed coverage and unobserved effort were both well represented. By breaking down the observer data by month and region, four time-areas were identified for which observer coverage was consistently high (concentrated) and where there was also a high level of unobserved effort (Figure 1). Three of these regions (Regions 1, 3 and 4) had almost 20% observer coverage while the region with the greatest effort had almost 10% coverage (Region 2) (Table 2). These areas were selected for further analysis based on the premise that comparisons made in these time-areas would be more meaningful than comparison across the entire fishery, and could act as indicators of reporting reliability within the fishery.

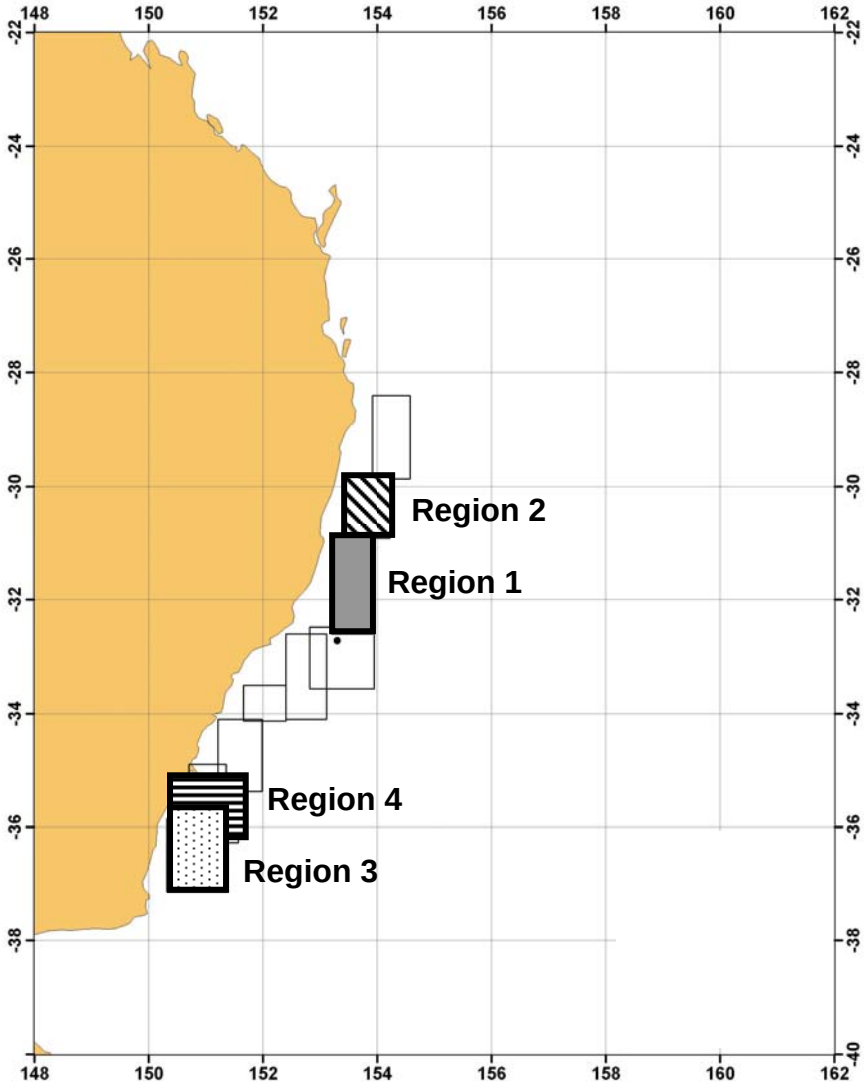


Figure 1 – Four regions selected for comparative analyses of observed and logbook reported catch rates and discards rates. Only data pertaining to months in which there was ~10-20% observer coverage were used for each regional analysis. Regions 3 and 4 overlap in area but not in the time periods for which data were selected. Also shown are other regions considered but rejected based on observer coverage levels being too low for the months in which observers were present.

Table 2 – Observed and unobserved effort and percentage observer coverage for each of the four regions selected for comparative analyses of catch and discard rates.

Zone	Reporting System	Effort (hooks)	Operations	%Coverage
1	LOGBOOK	209202	219	
1	OBSERVER	49292	57	19.07
2	LOGBOOK	474696	535	
2	OBSERVER	52166	57	9.90
3	LOGBOOK	98600	117	
3	OBSERVER	23980	29	19.56
4	LOGBOOK	216990	227	
4	OBSERVER	50182	55	18.78

Once the time-areas for comparative analyses were selected, mean catch rates and mean discard rates for each region and each species were calculated, and the means of the observed and unobserved samples compared using the Wilcoxon Significance Test for the difference between two means from non-normally distributed samples (S-Plus v6.0 Professional).

Comparative analyses of logbook and observer data indicated that for 13 of the species considered, observed retained catch rates were significantly greater than reported retained catch rates in at least one of the four time area strata examined (Table 3). For 3 species (black oilfish, oilfish and skipjack tuna), significantly greater observed catch rates were apparent in 3 or more of the time-areas assessed. In contrast, rudderfish observed catch rates were significantly less than reported in all 4 time-areas. Discussions with observers and the Australian Fisheries Management Authority has revealed that the misreporting of black oilfish and rudderfish species is most likely due to fisher's mistakenly recording black oilfish in the rudderfish field in the logbooks. Why the difference between observed and reported skipjack catches is

Table 3 – List of the number of time-area strata for which the observed longline catch rates and observed longline discarding rates were significantly greater ($p<0.05$) than reported in longline logbook data. Four time–area strata were selected off the east coast of Australia based on high observer coverage (~10-20%) and high unobserved fishing effort.

Species	Areas (Catch rates)	Areas (Discarding rates)
Yellowfin Tuna	2	4
Southern Bluefin Tuna	0	0
Bigeye Tuna	0	2
Albacore Tuna	1	4
Striped Marlin	0	0
Broadbill Swordfish	1	2
Ray's Bream	2	1
Dolphinfish	1	2
Rudderfish	4 (over-reported)	0
Shortfin Mako	0	1
Blue Shark	1	2
Bronze Whaler	0	0
Oceanic Whitetip Shark	1	0
Scalloped Hammerhead	1	0
Wahoo	0	0
Tiger Shark	0	1
Shortbilled Spearfish	1	2
Black Oilfish	4	4
Oilfish	3	2
Moonfish	1	0
Blacktip Sharks	0	1
Northern Bluefin Tuna	0	0
Skipjack Tuna	4	3
Porbeagle Shark	0	0

so apparent is uncertain and may require further discussion with fishers. For 10 of the species assessed, there was no significant difference between reported and observed catch rates in any of the 4 time-areas examined.

Observed discard rates were greater than reported in unobserved logbooks in at least one time-area for 14 of the species considered here. For albacore tuna, yellowfin tuna and black oilfish, observed discard rates were significantly higher than reported in all four time-areas, while observed dolphinfish, blue shark, shortbill spearfish, oilfish, skipjack tuna, bigeye tuna and swordfish discards were higher in two of the time-areas. There was no significant difference between observed and reported discard rates for 10 of the species assessed. For 5 of these species, there were no discards reported or observed at all during the time period assessed.

The extent of underreporting of species discards and catches did not appear to vary a great deal between regions, with 8, 7, 7 and 9 instances of possible misreporting apparent in regions 1, 2, 3 and 4 respectively.

Overall the results suggested that evidence for under-reporting, while not a consistent phenomena across species or time-areas, may be a significant factor of concern for fishery managers and scientists wishing to use such data within assessments, and reinforces the importance of observer coverage for gaining a realistic understanding of species catches and discarding. Because catches may in some cases be underreported, the economic value of the fishery, and of individual species economic importance, is likely to constitute an underestimate when based on logbook catch figures. This study has not attempted to scale up catches and value based on observer statistics, partly because the observer coverage has been limited spatially to date (very little offshore coverage). However, such analyses may be possible in future.

Temporal trends in catch and economics, catch rates and discarding for byproduct species

The reported catch weight of the byproduct taken by domestic longliners off eastern Australia fluctuated between 74-209 mt between 1987-1993 before increasing to 652 mt by 1996 and in recent years to between 1100-1321 mt/yr (Figure 2). While total byproduct catch has increased, so to has total target species catches, and the percentage of reported catch comprising byproduct has tended to fluctuate between 10-20% of the total over the period 1987-2003, peaking in the period 1994-1996 (19-21%).

Five species of byproduct make up over 90% of catch and associated value of longline byproduct taken off eastern Australia (excluding shark fin – discussed below). In 2003, these included albacore tuna (40.7% of total byproduct value), dolphinfish (25.4%), rudderfish (14.6%), shortfin mako (5.2%) and black oilfish (5.6%).

Byproduct was estimated to account for a relatively small component of fishery GVP, being just over 6% (~$3 million) of GVP in the eastern Australian longline fishery in 2003. Total catch and value of byproduct will be underestimated in the current report due to underreporting of at least some of these species, and uncertainty over the amount and value of shark fin, but the current ongoing observer program should allow more precise estimates in the next few years. If striped marlin is included as

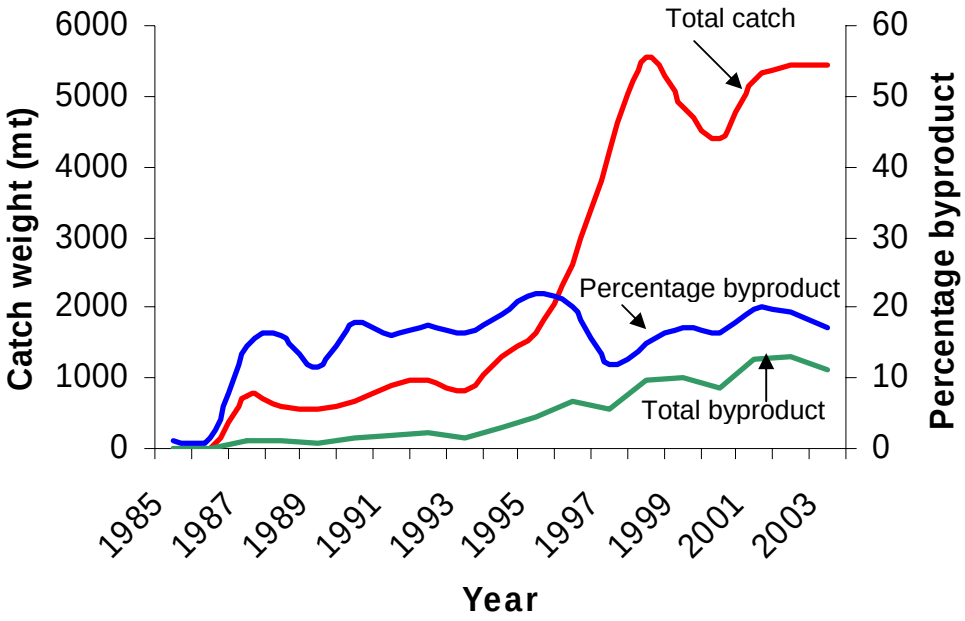


Figure 2 – Total catch (mt) and the percentage of catch comprising byproduct species by domestic longliners off eastern Australia.

byproduct rather than target, then byproduct comprised over 12% of the eastern fisheries GVP in 2003.

Spatial and temporal trends in catches

There is considerable spatial and temporal (within year) variability in retained catch and discarding of byproduct in the eastern longline fishery. Therefore the contribution different species make to fishery economics varies spatially. Many of the economically important species (bigeye tuna, yellowfin tuna, striped marlin, albacore tuna, rudderfish, shortfin mako) are caught and retained throughout the extent of this fishery. Ray's bream and porbeagle shark are reported mostly from the southern regions of the fishery. Dolphinfish, oceanic whitetip shark and wahoo are reported mainly from the mid and northern regions. Swordfish, shortbill spearfish and northern bluefin tuna retained catch rates are highest in the mid latitude offshore regions of the fishery. Blacktip, tiger and scalloped hammerhead sharks tend to be caught/retained in near coastal (on shelf) waters.

Figures 4a-c describes spatial and seasonal variation in retained catches for each of three key byproduct species in the eastern fishery (another 16 byproduct species are described in the main report).

Albacore tuna: Albacore tuna is the major byproduct species in the eastern domestic longline fishery. Little catch is taken in the 1st or 4th quarters, excepting in a small area off Ulladulla/Bermagui in the southeast (Figure 4a). Most of the catch is taken in the 2nd and 3rd quarters in southeast waters that stretch down to Tasmania in the 2nd quarter. This high catch zone contracts northwards in the 3rd quarter, to centre off the central eastern coast (Coffs Harbour to Mooloolaba) and offshore waters east of this. Higher catches are also reported near Cairns in these quarters. With the exception of waters southeast of Tasmania (discarding rates 50-100%), logbook records indicate

very little or no discarding of albacore tuna throughout the fishery, at all times of year. Reported catch of albacore tuna in the eastern Australian longline fishery increased from 21 mt (1986/7) to 460 mt (1995/6) and has since varied between 300-500 mt, with the exception of the peak season of 640 mt (~57000 fish) in 2001/2. Albacore tuna comprise the major byproduct species (by catch weight) taken throughout most of the eastern fishery. In recent years this species has made up approximately 6-10% of total annual catch in this fishery. Overall mean annual discarding rates are among the lowest for any species (0.8-1.3%) in recent years.

Dolphinfish: Dolphinfish are a major byproduct species in Australias eastern longline fishery. The majority of the retained catch is taken in the 4th quarter off Mooloolaba, 1st quarter off Cairns and Mooloolaba and extending down the southeast coast, with a similar catch pattern in the 2nd quarter (Figure 4). Logbook records indicate relatively little discarding in the fishery in the 4th and 1st quarters, higher levels east of Mooloolaba in the 2nd quarter, and high levels off Cairns in the 3rd quarter. Catch records prior to 1996 are almost non-existent for this species, as it was not listed in the predominant logbook prior to this time. Reported catch in the eastern longline fishery increased from 9 mt in 1995/6 to 178 mt in 1998/9, dropped to 56.6 mt in 1999/2000, peaked at 329 mt (40200 fish) in 2001/02 before dropping to 166 mt in 2002/03. Dolphinfish catch in this fishery makes up a major proportion of total byproduct (in terms of relative catch weight) north of 30ºS. This species makes up 2-4% of total annual fishery catch. Reported discarding percentages in recent seasons have ranged between 5-28%.

Shortfin mako shark: Shortfin mako is a significant byproduct species in the domestic eastern longline fishery. The majority of the retained catch is reported in near coastal waters off Mooloolaba down to Bermagui, particularly in the 2nd and 3rd quarters, with a lower proportion of retained catch taken offshore between 25ºS-30ºS throughout the year (Figure 4). Logbook records indicate a high proportion of shortfin mako are discarded north of 20ºS, in offshore waters (158ºE-168ºE) and off southern Tasmania, in all quarters. Lower proportions are discarded in other ETBF areas. Catch records prior to 1996 are almost non-existent for this species, as it was grouped under mako shark (including longfin mako). Reported catch in the eastern longline fishery increased from 21 mt in 1995/6 to peak at 181 mt (4600 fish) in 1999/2000, before declining to 89.9 mt in 2002/03. Shortfin mako are the predominant shark species retained between 20ºS-40ºS. This species makes up 1-3% of total annual catch and reported discarding percentages in recent seasons have ranged between 2-19%.

Spatial and seasonal variation in the occurrence and availability of different byproduct species produces variability in the economic contribution of species to fisher's income, and will be dependant in part on where a fisher is based, how far they can travel and their ability to access offshore waters. Consequently, whole of fishery or species specific management options can have different economic implications for fishers in different regions.

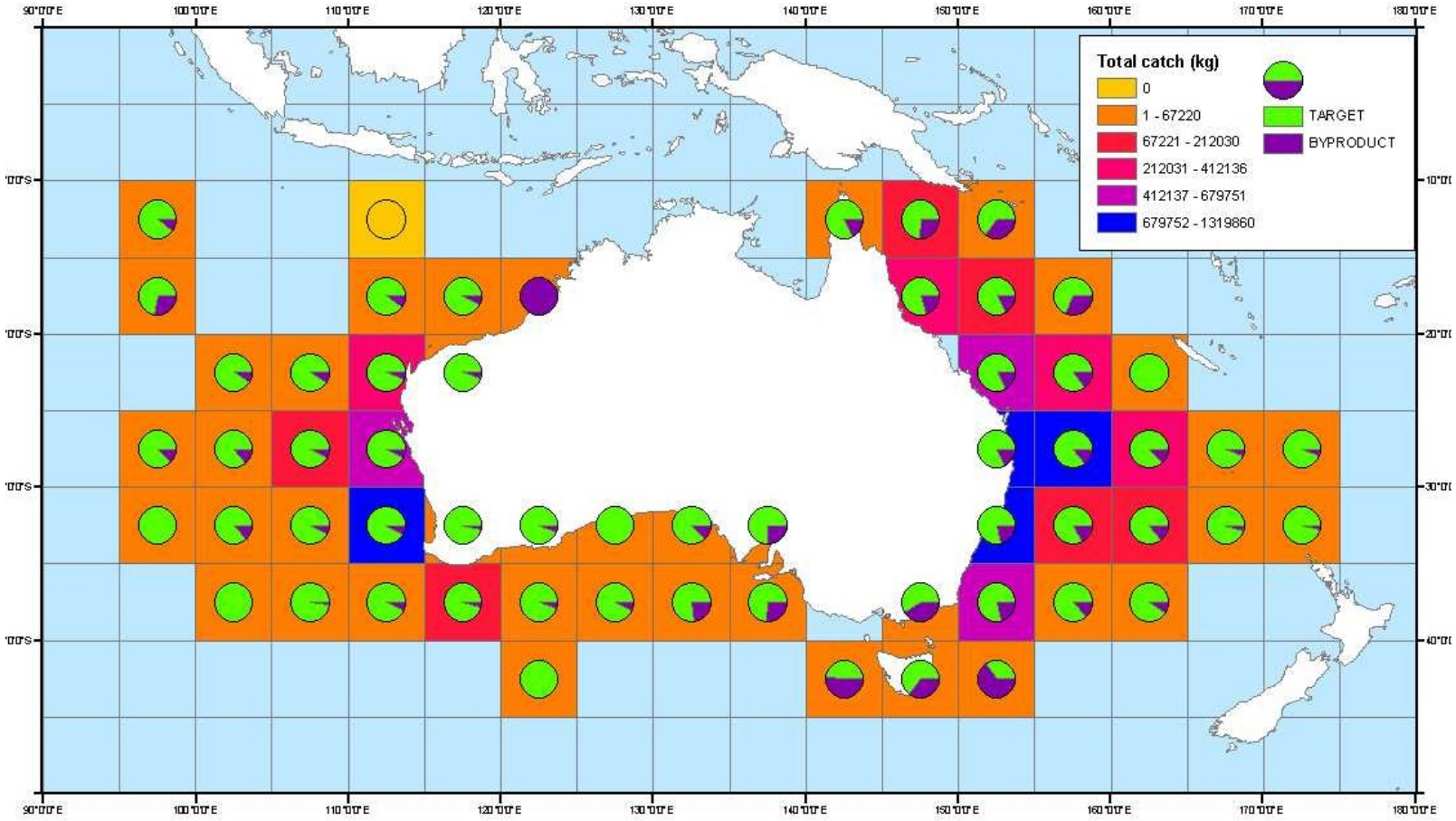


Figure 3 – Proportion of byproduct to target species catch retained by 5 degree squares in Australias domestic longline fisheries for the period 1998-2003 (Data: AFMA, 2003).

ALBACORE TUNA

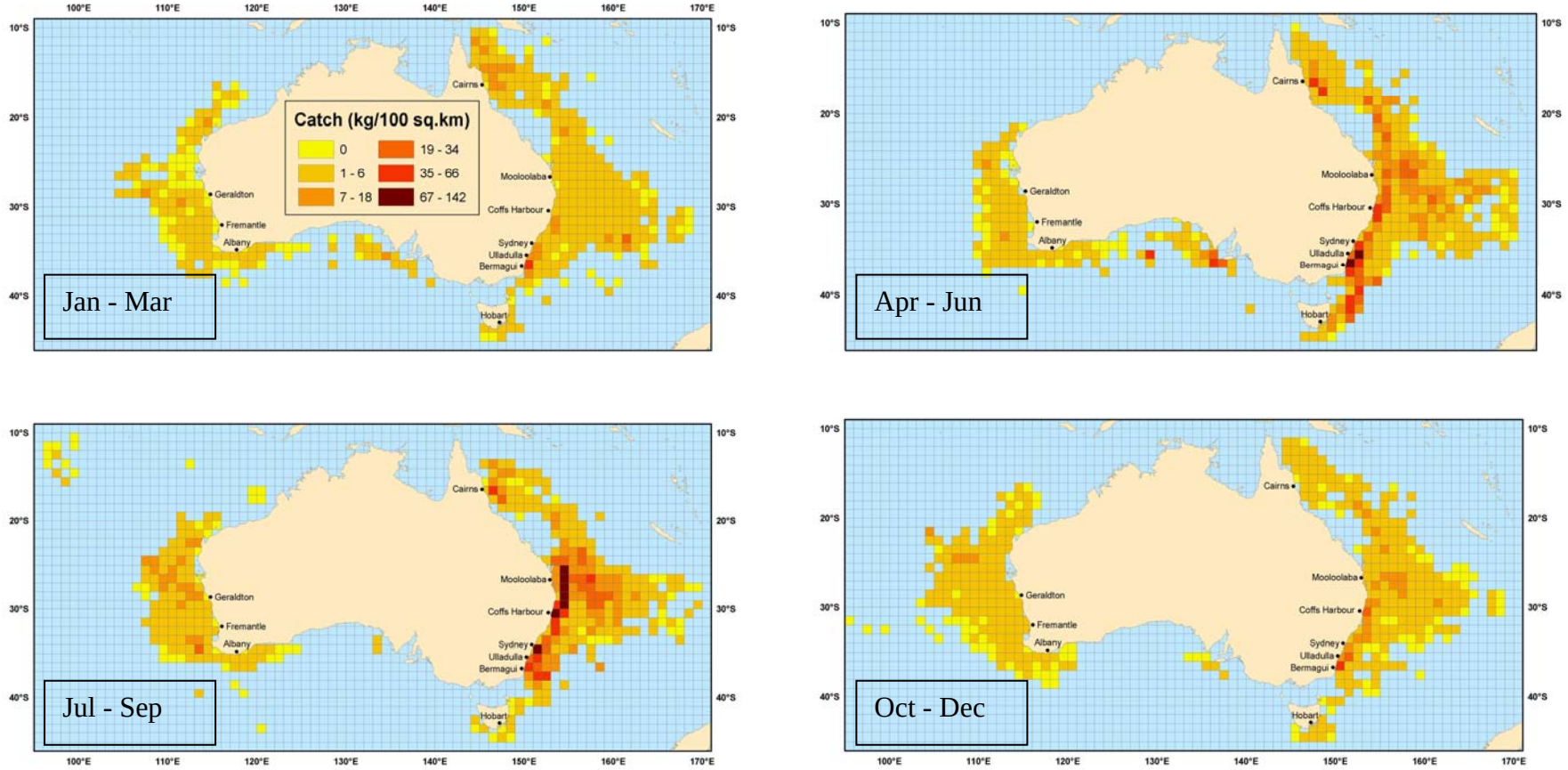


Figure 4a – Mean quarterly retained catch (kilograms per 100 km^2 for each 1º square) of albacore tuna taken by domestic longliners, for the period 1998-2002.

DOLPHINFISH

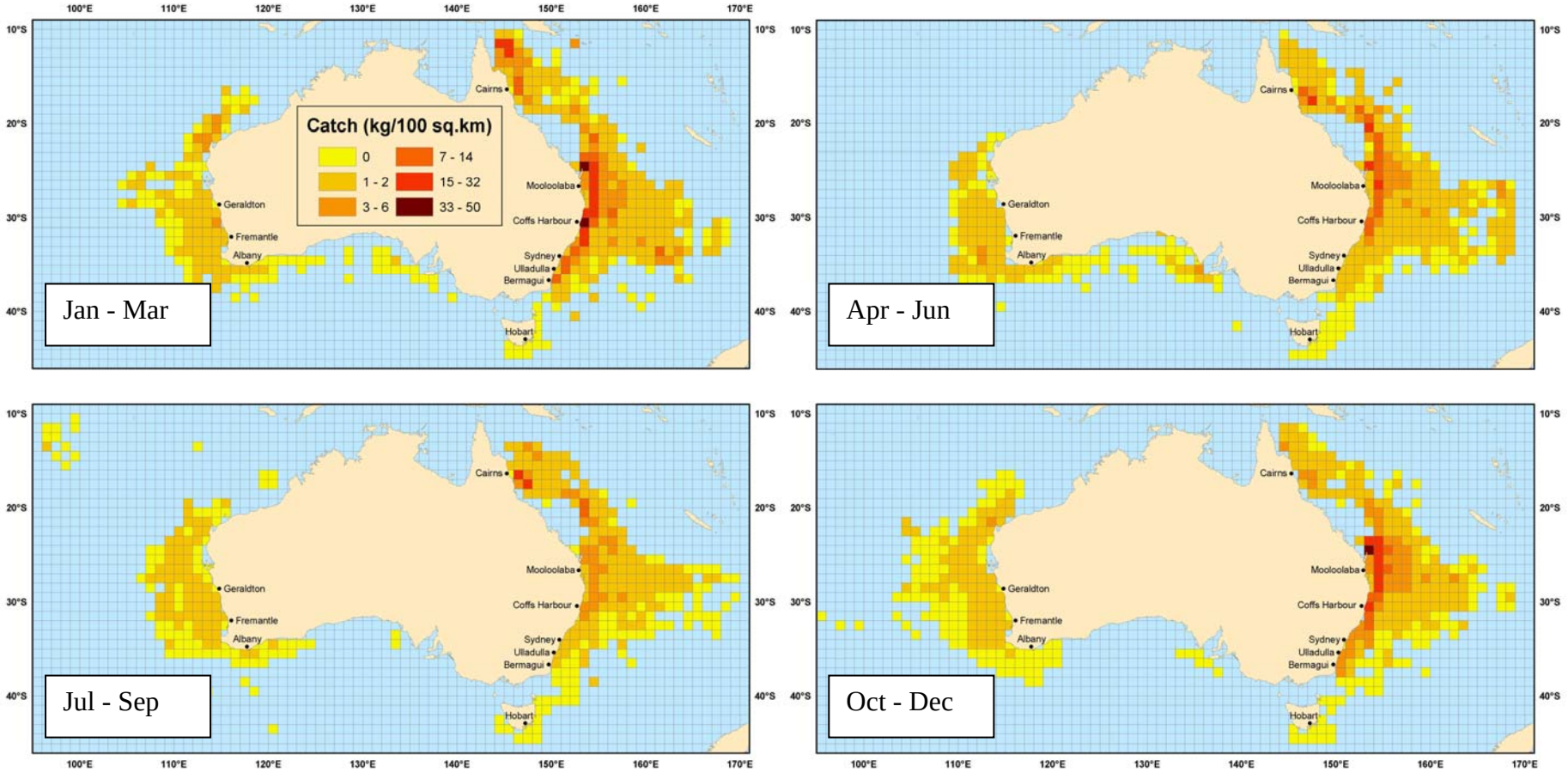


Figure 4b – Mean quarterly retained catch (kilograms per 100 km^2 for each 1º square) of dolphinfish taken by domestic longliners, for the period 1998-2002.

SHORTFIN MAKO SHARK

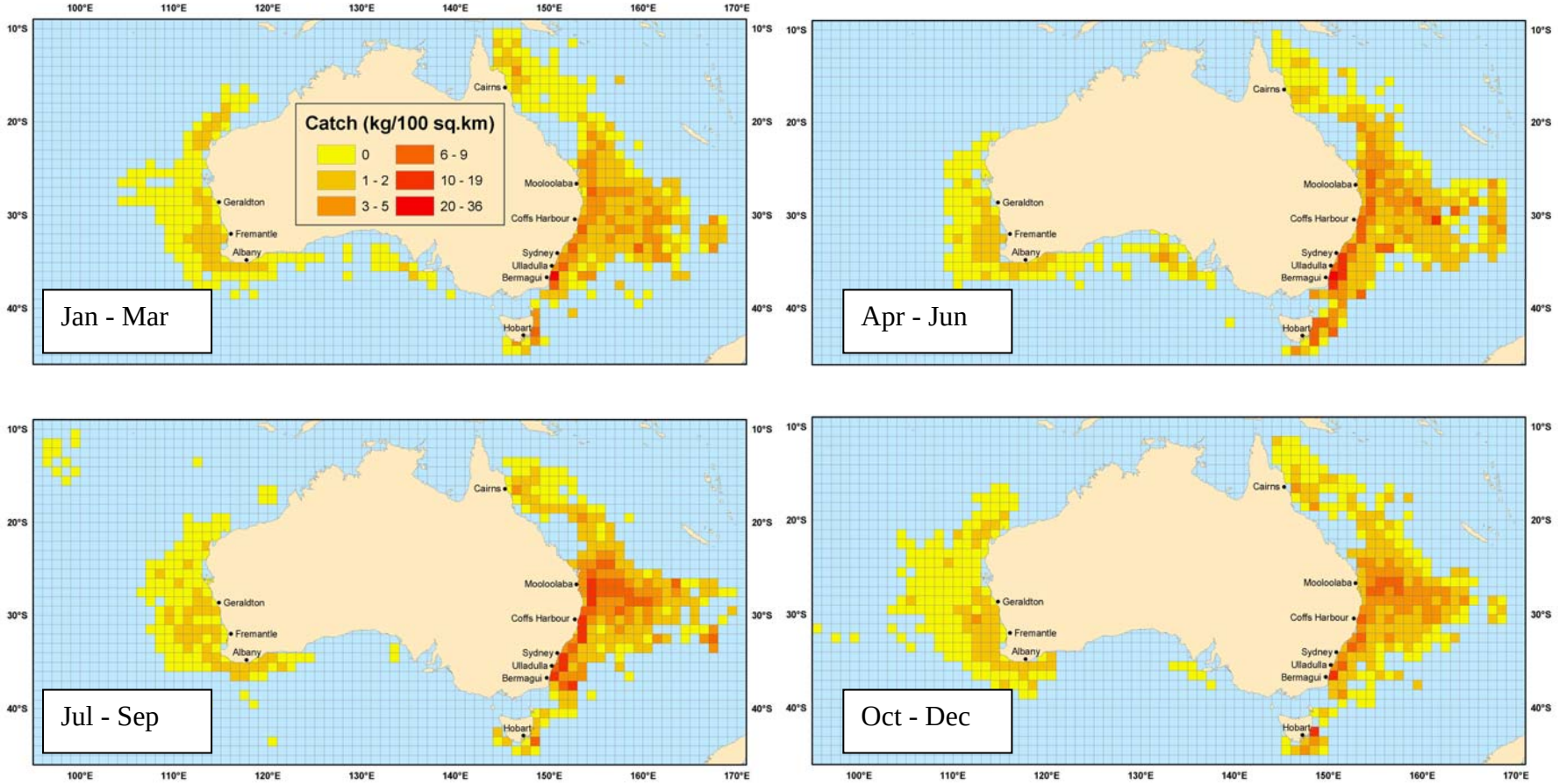
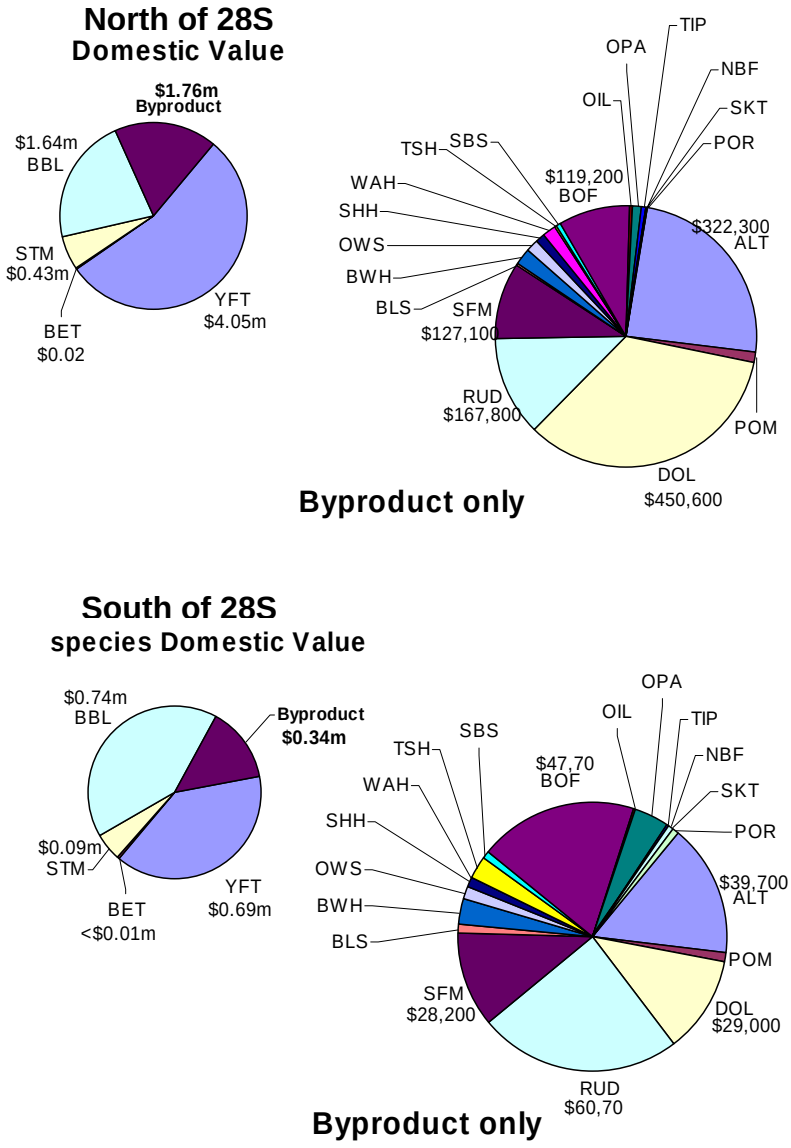
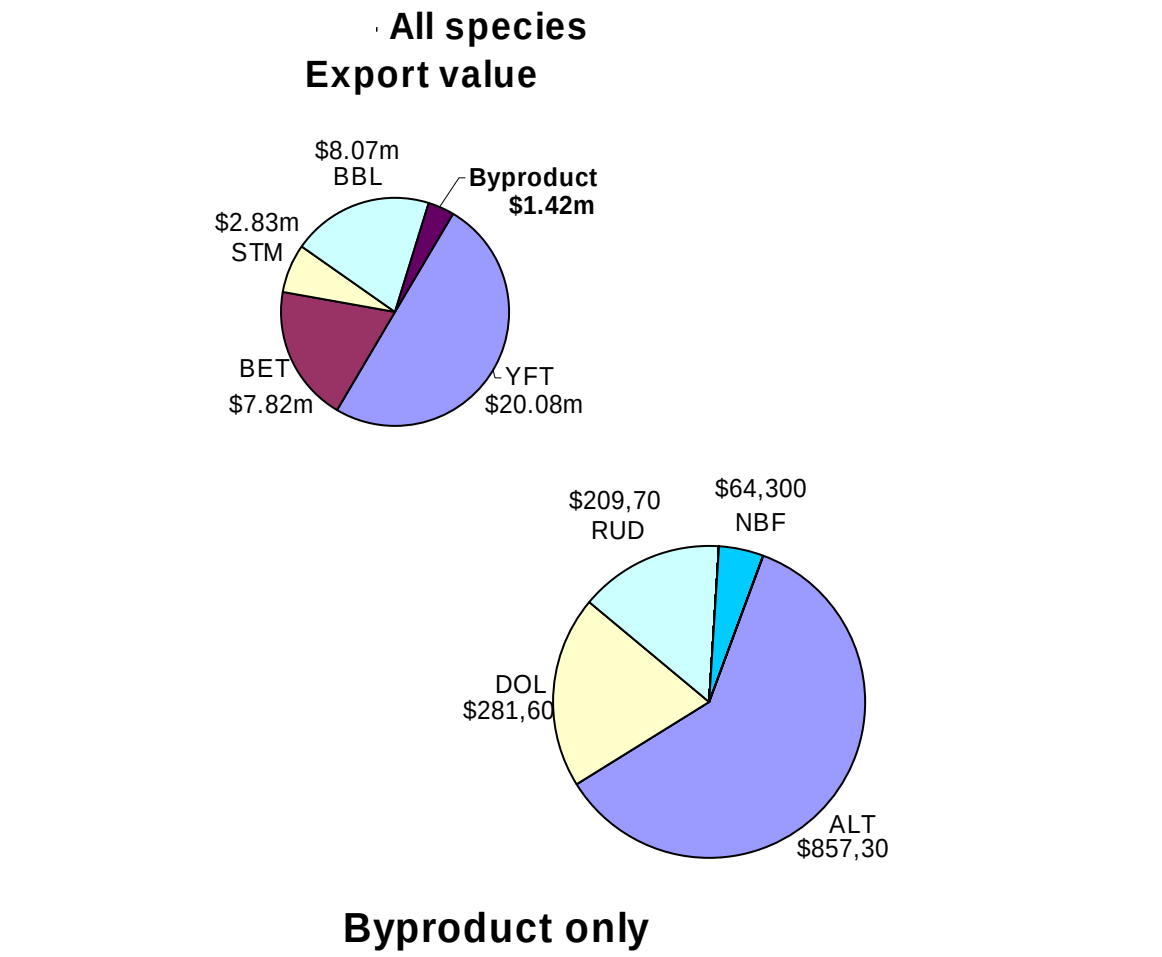


Figure 4c – Mean quarterly retained catch (kilograms per 100 km^2 for each 1º square) of shortfin mako shark taken by domestic longliners, for the period 1998-2002.



YFT - Yellowfin Tuna	**POM** - Ray's Bream	**OWS** - Oceanic Whitetip Shark	**OIL** - Oilfish
SBT - Southern Bluefin Tuna	**DOL** - Dolphinfish	**SHH** - Scalloped Hammerhead	**OPA** - Moonfish
BET - Bigeye Tuna	**RUD** - Rudderfish	**WAH** - Wahoo	**TIP** - Blacktip Sharks
ALT - Albacore Tuna	**SFM** - Shortfin Mako	**TSH** - Tiger Shark	**NBF** - Northern Bluefin Tuna
STM - Striped Marlin	**BLS** - Blue Shark	**SBS** - Shortbilled Spearfish	**SKT** - Skipjack Tuna
BBL - Broadbill Swordfish	**BWH** - Bronze Whaler	**BOF** - Black Oilfish	**POR** - Porbeagle shark

Figure 5 - Fish species value as a proportion of GVP of fish taken by domestic longliners a) North of 28S, and; b) South of 28S, in the eastern longline fishery and sold on the domestic market in 2003.



YFT - Yellowfin Tuna	**POM** - Ray's Bream	**OWS** - Oceanic Whitetip Shark	**OIL** - Oilfish
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BBL - Broadbill Swordfish	**BWH** - Bronze Whaler	**BOF** - Black Oilfish	**POR** - Porbeagle shark

Figure 6 - Fish species export value as a proportion of GVP of fish taken by domestic longliners in the eastern fishery in 2003.

Opportunities and threats to sustainable fisheries management

Increased fishing effort and increasing retention of byproduct species can present both opportunities and threats that fishery managers need to be aware of. Byproduct in the longline fishery represent a diverse assemblage of species which vary considerably in a number of key biological features (such as growth and reproductive parameters) that relate to the vulnerability of these species to overfishing. Some species may be relatively productive and, if assessed to be underfished, may represent potential for fishery development. For other species, such as sharks, increased retention or even targeting that can result due to high value components (e.g. fins) can represent a serious threat to their populations (or further threat, where effort and catch was already too high).

Determining sustainability of increased catches for a particular species requires a stock assessment, or at the very least, indicators of stock status and abundance. Poor levels of data collection for byproduct species and a lack of understanding of their biology and stock structure have precluded assessments being undertaken for most of these species. Therefore, in most instances, determining whether current or increased catches of a particular byproduct species are sustainable is simply not possible. Of the five key byproduct species, only albacore tuna has been formally assessed, with the southern Pacific stock classified as not overfished (Labelle and Hampton, 2003). Consideration of information pertaining to the status and vulnerability of a species to overfishing is of critical consideration for managers who may view byproduct species as offering potential for fishery development. Those byproduct species assessed as "high risk" under the CSIRO-led Ecological Risk Assessment (ERA) project would not represent species that might support increased fishery development and diversification.

In the absence of assessments for the majority of non-target species, the ERA has provided indicators of the ecological risk (high, medium or low) posed by the longline fisheries to each species. That project has indicated that the ecological risk posed by the eastern domestic longline fishery varies considerably on a species by species basis. All of the shark species considered in this report have been ranked as at high risk to longline fishing in that fishery. Many pelagic shark stocks are believed to have increased vulnerability to overexploitation due to low birth rates, slow growth and sexual segregation in distribution. Given current catches and discarding trends and the biological vulnerability, a number of the shark species considered in this report, such as blue shark and shortfin mako, warrant further biological investigation and assessment as a matter of priority.

Discarding

As market prices and opportunities change over time, species currently discarded may in future tend to be retained. This has occurred in the past for some species now considered byproduct species. Subsequently, if a new market did open up, the status and/or ecological risk associated with increased retention or even targeting should be one of the first considerations of fisheries managers. In Australias eastern longline fishery, lancetfish (31493 discards since 2001) and blue sharks (15111 discards) are

Table 3 – Total discard and catch numbers for species caught in the eastern longline fishery, as recorded in the AL05 logbook records (spanning 2000 to April 2003). Table lists the top 50 species according to discard numbers. Grey shades represent species not previously considered in this report. Source: AFMA, 2003.

Common name	Method	Discards (n)	Catch (n)	Discarding (%)
Lancetfish	Longline	31493	2545	92.52
Blue shark	Longline	15111	2241	87.09
Yellowfin tuna	Longline	7528	199337	3.64
Dolphinfish	Longline	6095	66400	8.41
Bigeye tuna	Longline	3747	70044	5.08
Blue marlin	Longline	3083	0	100.00
Black Marlin	Longline	2534	0	100.00
Bronze whaler shark	Longline	1876	2505	42.82
Broadbill swordfish	Longline	1708	86783	1.93
Ocean sunfish	Longline	1579	14	99.12
Oceanic whitetip shark	Longline	1519	1844	45.17
Albacore tuna	Longline	1287	106049	1.20
Shortfin mako	Longline	863	7370	10.48
Indo-pacific sailfish	Longline	840	476	63.83
Striped marlin	Longline	757	22509	3.25
Scalloped hammerhead	Longline	736	992	42.59
Tiger shark	Longline	651	470	58.07
Rudderfish	Longline	537	60716	0.88
Blacktip sharks	Longline	319	404	44.12
Dusky shark	Longline	305	418	42.19
Oilfish	Longline	275	1986	12.16
Wahoo	Longline	200	3145	5.98
Manta ray	Longline	178	10	94.68
Thresher shark	Longline	169	168	50.15
Porbeagle	Longline	168	206	44.92
Southern bluefin tuna	Longline	161	1309	10.95
Barracouta	Longline	152	46	76.77
Skipjack tuna	Longline	141	2336	5.69
Other	Longline	140	52	72.92
Shortbill spearfish	Longline	129	2166	5.62
Black oilfish	Longline	89	12127	0.73
Rays Bream	Longline	41	7611	0.54
Southern Frostfish	Longline	31	2	93.94
Ray	Longline	29	0	100.00
Stingray	Longline	27	0	100.00
Dealfish	Longline	17	0	100.00
Silky shark	Longline	13	19	40.63
Oarfish	Longline	12	19	38.71
Opah/Moonfish	Longline	9	526	1.68
Mackerel	Longline	8	18	30.77
Northern Bluefin tuna	Longline	6	91	6.19
Grey Nurse shark	Longline	5	0	100.00
Shark "Other"	Longline	5	22	18.52
Crocodile shark	Longline	4	0	100.00
Black Kingfish	Longline	1	64	1.54
Cardinal Fish	Longline	1	2	33.33
Cookie cutter shark	Longline	1	0	100.00
Rainbow runner	Longline	1	5	16.67
Seven gilled shark	Longline	1	0	100.00

the two byproduct species most commonly hooked on longline gear. Other species commonly encountered and predominantly discarded include ocean sunfish and Indo-Pacific sailfish (Table 4).

Co-occurrence between byproduct and target species

Managers looking to restrict target species catches need to be aware that the key byproduct species occur in close association with the target species in many regions, hence target species based management measures will also significantly impact income derived from byproduct.

Co-occurrence analyses were undertaken in two stages. The first determined those byproduct species which are most commonly caught in sets taking any of the four target species. The second analyses assessed catch rates of economically important byproduct species (albacore tuna, dolphinfish and shortfin mako shark in the eastern longline fishery) against the main target species catch rates in the north, central and southern regions of the fishery.

Of all the byproduct species, albacore tuna has by far the highest degree of co-occurrence with each of the target species. It is taken in 79-89% of sets taking yellowfin tuna, 42-71% of sets taking bigeye tuna, 44-65% of sets taking striped marlin and 52-63% of sets taking swordfish, depending on region and whether day or night sets. Dolphinfish also has a high degree of co-occurrence across target species, particularly in the central and northern region of the fishery, occurring in 45-67% of sets in these regions, depending on target species. Rudderfish co-occurrence may be high but there is uncertainty over species recording and identification (e.g. some fishers report black oilfish as rudderfish) in logbooks. Shortfin mako commonly co-occur with swordfish and striped marlin in the southern ETBF.

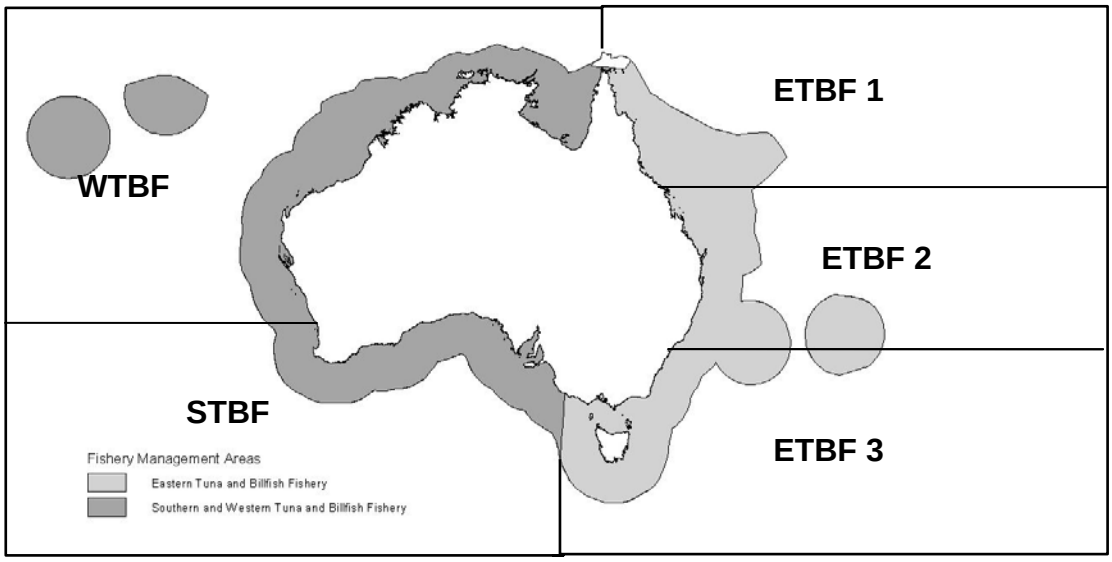

Figure 7 - Subregions within the eastern (ETBF) and western (SWTBF) longline fisheries used for analyses of co-occurrence between target and byproduct species. Note, only results for the eastern fishery are contained in this summary report.

A subsequent comparison of catch rates between key byproduct and target species in each region indicated evidence for positive relationships (whereby high catch rates of the target species are associated with high catch rates of the byproduct species and vice versa) between catch rates for albacore tuna and bigeye tuna, and in some regions between blue shark and swordfish, and shortfin mako and any of the target species (see Bromhead et. al 2005). In addition, high catch rates of dolphinfish were associated with sets taking significant numbers of yellowfin tuna. Variation around mean estimates in these analyses were large and future analyses might look to narrow the spatial-temporal scales examined.

Summary and Conclusions

Australia's pelagic longline fisheries are currently facing a difficult economic outlook, with overcapacity, localised depletions, lowered availability of target species, and reduced access to some export markets placing considerable pressure on operators and processors alike. Under such circumstances, byproduct can become a relatively more important part of some fishers' catch and income. The following represents the key points managers need be aware of when considering management of byproduct species:

1. Some species catches and discarding are likely to be underreported, meaning total catch and economic value will be underestimated until scaling factors based on appropriate coverage of observer data can be determined.

2. Total reported byproduct catches have increased with the expansion of the domestic longline fisheries, with only 5 of these species (albacore tuna, dolphinfish, rudderfish, shortfin mako, and black oilfish) comprising over 90% of the total catch and associated economic value of byproduct.

3. Byproduct was estimated to account for just over 6% (~$3 million) of GVP in the eastern longline fishery in 2003. Total catch and value of byproduct will by underestimated in the current report due to underreporting of some species, and uncertainty over the amount and value of shark fin. Determining trends in byproduct value over time will be difficult in the absence of processor data from before 2003, but market data has provided some indicators for individual species.

4. The relative contribution of each species to byproduct catch and value varies considerably by area and time of year. In addition, trends in target-byproduct species co-occurrence also vary spatially and temporally. Such variation implies that whole of fishery or species specific management actions will have very different impacts on fisher's income depending on where they are based and how far they can travel.

5. The catch of byproduct species represents both opportunities and threats for sustainable fisheries. Albacore tuna is an easily targeted, relatively high value, abundant species that has been assessed as underfished and which may offer potential for fishery development.

Table 5.2: Percentage co-occurrence in only those shots containing the target species YFT (top) and BET (below), for each region, by time (2000-2003 data). Only those byproduct species co-occurring in greater than 25 % of these shots are shown.

Target Species	Co-occur Species	Region					
		ETBF1		ETBF2		ETBF3	
		Day (n = 3639)	Night (n = 2835)	Day (n = 6778)	Night (n = 16593)	Day (n = 3604)	Night (n = 2190)
YFT	BET	43.34	70.83	43.33	68.87	42.59	70.82
	ALT	35.45	51.11	51.30	58.50	54.66	66.44
	STM	.	.	44.01	40.90	38.54	31.64
	BBL	.	59.68	38.57	80.60	25.55	63.06
	DOL	56.17	52.95	45.22	45.35	25.11	.
	RUD	29.93	30.51	.	35.62	38.85	52.15
	SFM	.	.	.	.	.	33.38
	BLS	.	.	.	.	.	.
	BWH	25.58	.	.	.	.	.
	WAH	36.58	.	.	.	.	.

Target Species	Co-occur Species	Region					
		ETBF1		ETBF2		ETBF3	
		Day (n = 1690)	Night (n = 2230)	Day (n = 3263)	Night (n = 13546)	Day (n = 1651)	Night (n = 1784)
BET	YFT	93.31	90.04	90.01	84.36	92.97	86.94
	ALT	42.19	58.65	62.21	62.36	63.29	70.68
	STM	.	.	40.33	37.99	36.64	30.33
	BBL	.	63.72	49.07	82.05	33.62	70.07
	DOL	51.54	54.35	46.40	45.25	.	.
	RUD	33.73	28.48	33.16	38.85	43.79	53.87
	SFM	.	.	.	.	.	34.92
	BLS	.	.	.	.	.	.
	BWH	25.50	.	.	.	.	.
	WAH	29.64	.	.	.	.	.

Table 5.4: Percentage co-occurrence in only those shots containing the target species striped marlin (STM –top) and broadbill swordfsih (BBL-bottom), for each region, by time (2000-2003 data). Only those byproduct species co-occurring in greater than 25 % of these shots are shown.

Target Species	Co-occur Species	Region					
		ETBF1		ETBF2		ETBF3	
		Day (n = 334)	Night (n = 452)	Day (n = 3350)	Night (n = 8435)	Day (n = 1606)	Night (n = 858)
STM	YFT	95.21	92.04	89.04	80.45	86.49	80.77
	BET	36.53	71.24	39.28	61.01	37.67	63.05
	ALT	44.91	65.49	47.28	52.09	44.02	56.53
	BBL	.	82.96	40.03	84.18	.	69.81
	DOL	67.37	61.73	46.12	44.22	29.89	30.89
	RUD	.	.	.	33.40	37.24	51.40
	SFM	.	.	.	.	.	38.69
	BLS	35.03	.	.	.	.	.
	BWH	32.34	.	.	.	.	.
	OWS	33.23	.	.	.	.	.
	WAH	40.42	.	.	.	.	.
	BLM	31.14	.	.	.	.	.

Targ et Species	Co-occur Species	Region					
		ETBF1		ETBF2		ETBF3	
		Day (n = 548)	Night (n = 1897)	Day (n = 2971)	Night (n = 16784)	Day (n = 1044)	Night (n = 1774)
BBL	YFT	92.52	89.19	87.98	79.68	88.22	77.85
	BET	56.39	74.91	53.89	66.22	53.16	70.46
	ALT	52.01	61.10	54.16	56.22	58.72	63.59
	STM	.	.	45.14	42.31	37.74	33.77
	DOL	59.67	58.46	46.35	44.86	28.54	26.49
	RUD	34.85	25.46	32.92	38.06	43.10	50.06
	SFM	.	.	.	.	29.69	36.75
	BLS	.	.	.	.	.	.
	WAH	29.93	.	.	.	.	.

6. Unfortunately, the status of most byproduct species is unknown and management is currently relying on assessments of the ecological risk posed by longline fisheries to byproduct species, something that varies on a species-wise basis. Discarding of byproduct is also an issue of significant concern, both from resource wastage and sustainability viewpoints.

7. Overall, the management of most byproduct is likely to be driven primarily by concerns over the sustainability of catches of many of these species, as opposed to incentives and potential for wealth generation and productivity (with perhaps the exception of species like albacore tuna).

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