NSW DPI Game Fish Tagging Program
Program Summary and Report to July 2005

Introduction to this Report

The Game Fish Tagging Program of NSW Department of Primary Industries (Formerly NSW Fisheries) has been in operation since 1973. Annual reports for the program were produced until 1997. Since then, there have been intermittent reports, the most recent being a summary of the program by Danielle Williams, published in the GFAA Journal for 2002. That summary provided information on the numbers of fish tagged and recaptured as at February 2001. This report provides a more extensive historic summary of the Program and its results, including data up to July 2005.

A little history

The concept of anglers tagging gamefish as part of a scientific program extends back at least 40 years. Cooperative tagging began in the USA in the early 1960s when Frank Mather III, working at the famous Woods Hole Oceanographic Institute, invented a tag which could be easily placed into the shoulder of large fishes such as tuna and marlin – importantly, without having to remove them from the water. These tags, which are essentially similar to the ones used today, were distributed to a number of gamefish anglers on a trial basis. Subsequent trials on both bluefin tuna and white marlin proved very successful and cooperative gamefish tagging had begun. The word spread, and it was in 1968 that the first gamefish was tagged in Australia, a black marlin tagged and released off the Great Barrier Reef by radio star Bob Dyer using one of Frank Mather's tags. (To be completely accurate, pioneer Australian angler Athel D'Ombrain actually tagged several marlin off Port Stephens in the early 1940s using brass discs attached to their tails, but organized gamefish tagging as we know it in Australia today commenced with Bob Dyer's first release).

Over the next five years or so, nearly 1,000 black marlin were tagged by the growing charter fleet off the Great Barrier Reef, all with American tags. However, with the idea of fostering tagging in other parts of the country, well known gamefisher Peter Goadby, together with past President of GFAA, John O'Brien, decided that there needed to be an Australian tagging program. They approached the then Director of NSW Fisheries, Dr Don Francois, found a sympathetic ear, and the Australian gamefish tagging program was officially launched in December 1973. Tagging commenced in earnest the following year and numbers of fish tagged and recaptured began to slowly increase.

Growth of the Program

The growth of the tagging program is perhaps best illustrated by Figure 1, showing the numbers of fish tagged each year. This clearly records a remarkable increase in numbers tagged for the first 14 years of the program, peaking at over 14,700 fish tagged in 1987. Numbers then dropped off for several years before a massive increase in the El Nino year of 1991, when an incredible 17,994 fish were tagged – still a record. Since then, the number of fish tagged each year has fluctuated, in most years exceeding 10,000. The last year, 2004/2005, recorded the largest number tagged for the previous six years (just under 13,000 fish).

The grand total of fish tagged on the Program to the end of June 2005 stood at just over 301,000, continuing this program's status as one of the largest of its kind in the world.

Figure 1. Numbers of fish tagged each year

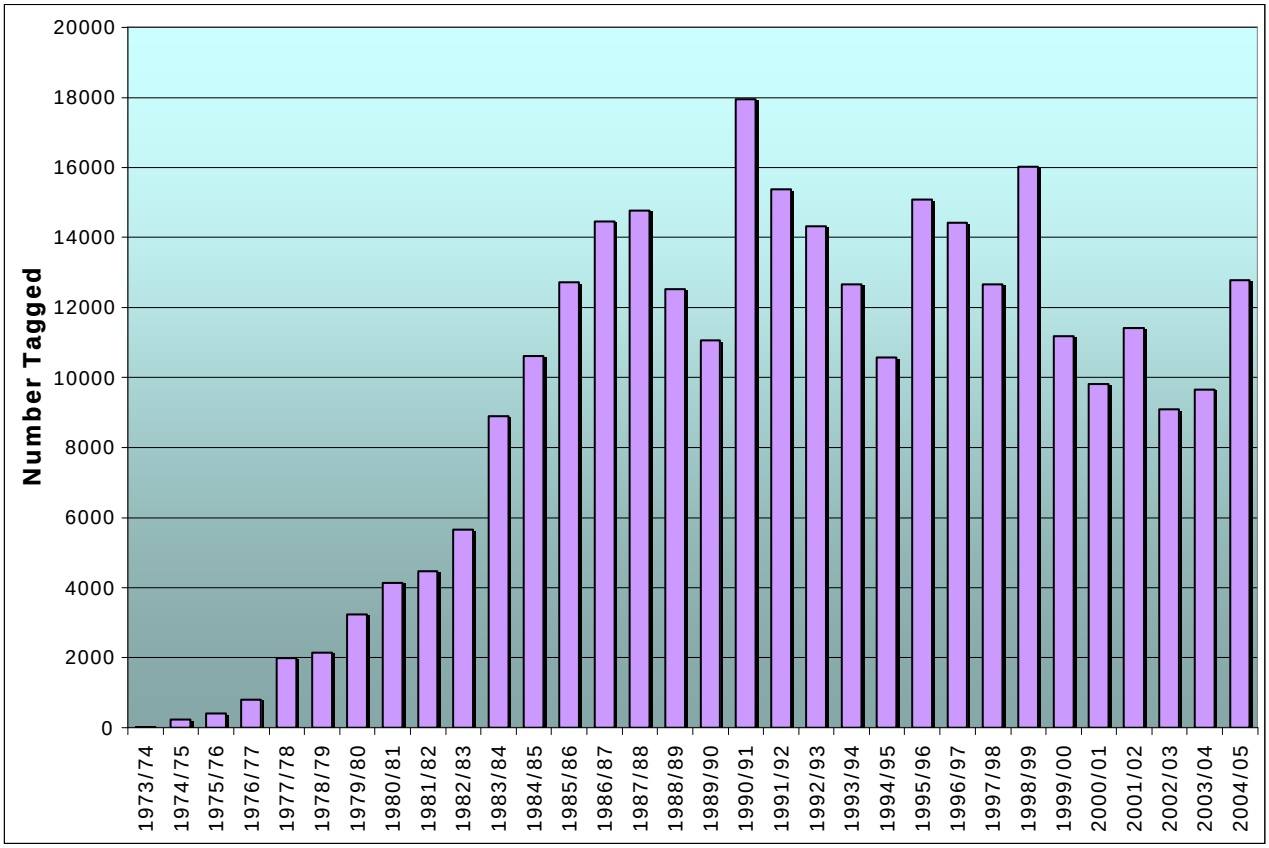


Table1. Numbers of fish tagged and recaptured to July 2005

Species	No.Tagged	No.Recap	% Recap
BLACK MARLIN	41146	314	0.76
YELLOWFIN TUNA	29275	615	2.1
YELLOWTAIL KINGFISH	27891	1937	6.94
SAILFISH	20809	226	1.09
DOLPHIN FISH	18699	175	0.94
MACKEREL TUNA	16750	54	0.32
STRIPED TUNA	16406	59	0.36
STRIPED MARLIN	13908	137	0.99
ALBACORE	13818	154	1.11
BONITO	13009	216	1.66
AUSTRALIAN SALMON	8141	559	6.87
SILVER TREVALLY	6745	192	2.85
SPANISH MACKEREL	5831	64	1.1
MAKO SHARK	5534	134	2.42
HAMMERHEAD SHARK	4674	51	1.09
WHALER SHARK	4509	91	2.02
TAILOR	4027	122	3.03
BRONZE WHALER	3846	85	2.21
NORTHERN BLUEFIN TUNA	3838	57	1.49
BLUE MARLIN	3694	11	0.3
BLUE SHARK	3529	59	1.67
TREVALLY	3150	31	0.98
MISCELLANEOUS	2738	90	3.29
SOUTHERN BLUEFIN TUNA	2464	80	3.25
QUEENFISH	2315	9	0.39
BARRACUDA	2311	5	0.22
FRIGATE MACKEREL	1728	2	0.12
GIANT TREVALLY	1645	21	1.28
SNAPPER	1543	85	5.51
WATSONS LEAPING BONITO	1431	41	2.87
QLD SPOTTED MACKEREL	1373	11	0.8
RAINBOW RUNNER	1286	17	1.32
BARRACOUTA	1052	2	0.19
LARGE SCALE TUNA	961	4	0.42
SAMSON FISH	955	53	5.55
AMBERJACK	922	20	2.17
GOLD SPOTTED TREVALLY	921	13	1.41
WAHOO	833	4	0.48
BARRAMUNDI	780	29	3.72
BLACKTIP SHARK	767	29	3.78
TIGER SHARK	717	22	3.07
COBIA	707	17	2.4
MULLOWAY	536	36	6.72
SCHOOL SHARK	487	25	5.13
BIGEYE TREVALLY	463	6	1.3
DOGTOOTH TUNA	406	4	0.99
QLD SCHOOL MACKEREL	393	2	0.51
GUMMY SHARK	334	22	6.59
WHITE SHARK	286	10	3.5
SHORTBILL SPEARFISH	239	0	0
EAGLE RAY	160	2	1.25
BB SPANISH MACKEREL	154	1	0.65
TARPON	142	2	1.41
PORT JACKSON SHARK	136	8	5.88
BIGEYE TUNA	128	1	0.78
WHITETIP SHARK	126	2	1.59
THREADFIN SALMON	114	1	0.88
THRESHER SHARK	92	1	1.09
GREY NURSE SHARK	80	3	3.75
BROADBILL	78	2	2.56
ALMACO JACK	24	1	4.17
UNKNOWN	15	3	20
SNOOK	7	0	0
TOTAL	301078	6029	

Table 1 (above) presents a breakdown of the numbers of all fish species, or species groups, tagged since the Program began. This table also shows the number of fish recaptured, together with overall recapture rates for each species or species group. Many individual species of fish are able to be identified with relative ease by tagging anglers. However, in cases where identification to species level is unreliable, species are lumped into groups. The main groups in this regard are hammerhead and whaler sharks. Further, in the case of whaler sharks, various categories are sometimes recognized by anglers, but are unreliable as species identifications. These categories are bronze whaler, blacktip shark and whitetip shark, which are all lumped with whaler sharks for the purpose of any further analysis of results.

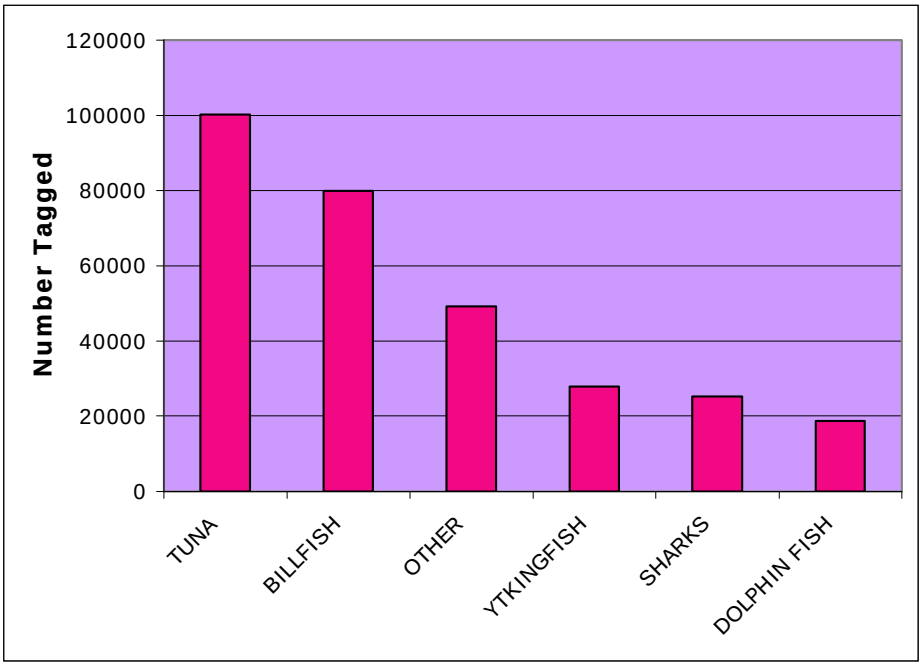
While most of the 60 species recognized as gamefish by the Game Fishing Association of Australia (GFAA) are eligible for tagging, and most of these have been tagged,

Table 1 indicates that just 10 species account for 70% of all fish tagged. These are: Black marlin, yellowfin tuna, yellowtail kingfish, sailfish, dolphin fish, mackerel tuna, striped tuna, striped marlin, albacore and bonito. Furthermore, the top 21 species (or species groups) make up 88% of the total number of fish released.

Looking at numbers of fish in major categories (Figure 2) shows that tuna as a group have been tagged in the largest numbers (33.3% of all releases) followed by the billfishes (26.5%). Of the other main species or species groups, yellowtail kingfish represent 9.3% of all fish tagged, followed by sharks (8.3%) and dolphin fish (6.2%). All other species combined constitute the remaining 16.4% of fish tagged.

One perhaps surprising aspect of this overall summary is that sharks are a relatively minor component of the program. Overall, a total of just over 25,000 sharks have been tagged, representing 8.3% of all fish tagged for the program.

Figure 2. Total numbers of fish tagged as major categories or species

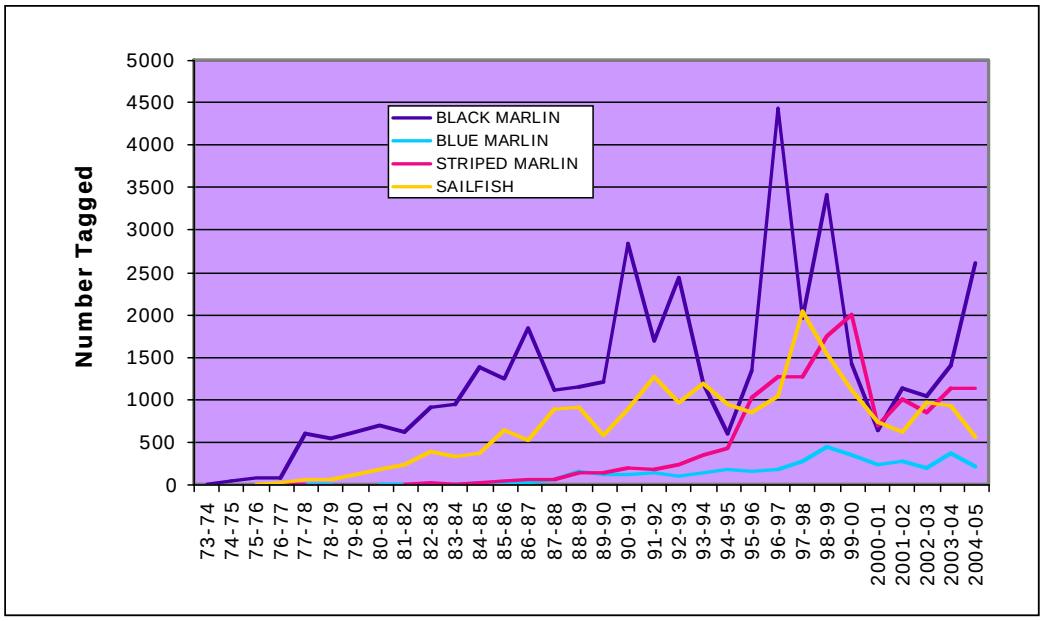


As mentioned, the main category of sharks tagged are the whalers, a group consisting of at least 10 or more species. Regarding single species of sharks, makos have been tagged in the greatest numbers (5,534) followed by blue sharks (3,529).

Changes in main species through time

Over the duration of the program, the numbers of each primary species tagged have fluctuated, often over wide ranges. While generally, numbers of a given species tagged in any year tend to reflect the relative abundance and availability of that species, there have been shifts in targeting of various species for tagging over the years.

Figure 3. Numbers of each major billfish species tagged each year



Numbers of billfish tagged have fluctuated considerably through time. Figure 3 shows that black marlin have tended to dominate billfish tagged numbers, but have had marked peaks and troughs, reflecting the availability of black marlin in those years. The sharp peaks for black marlin are due to intermittent pulses of large numbers of small fish (20-30kg) which appear unpredictably along the east coast. Numbers of striped marlin tagged increased markedly from about the mid 1990s while sailfish and blue marlin numbers have not fluctuated so markedly.

Figure 4. Numbers of each major tuna species tagged each year

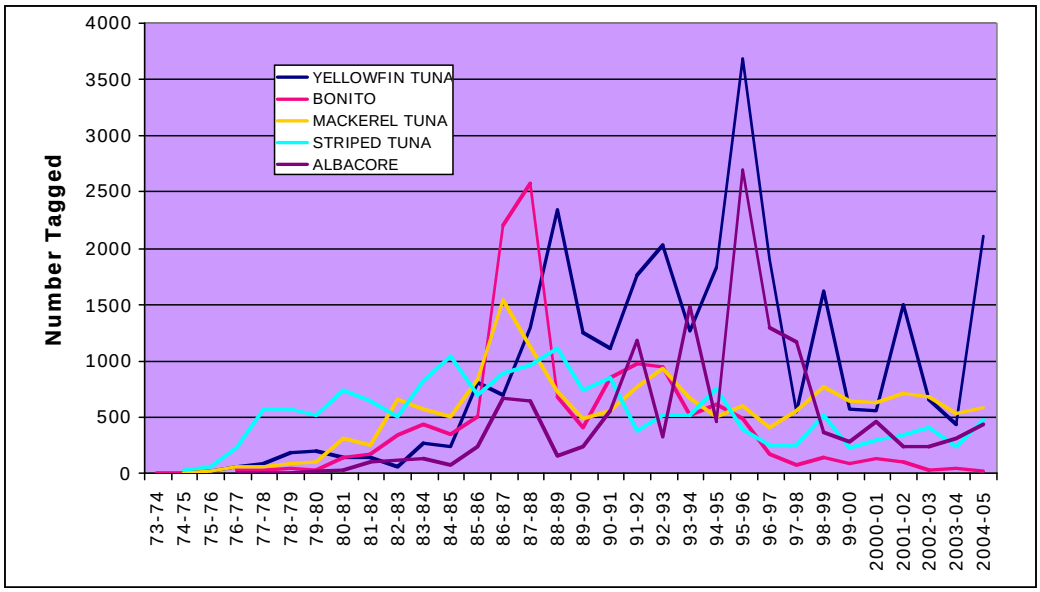
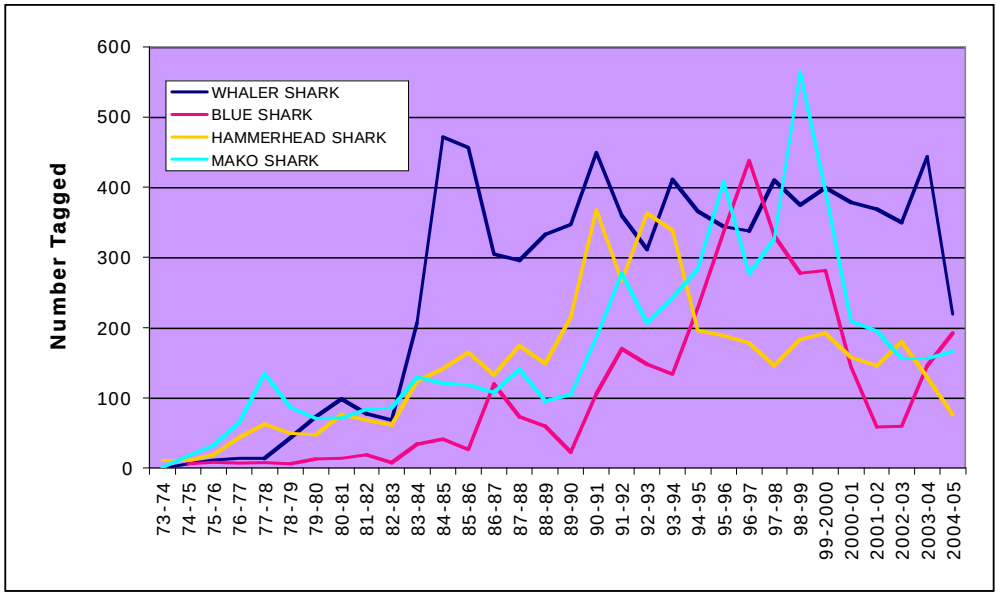


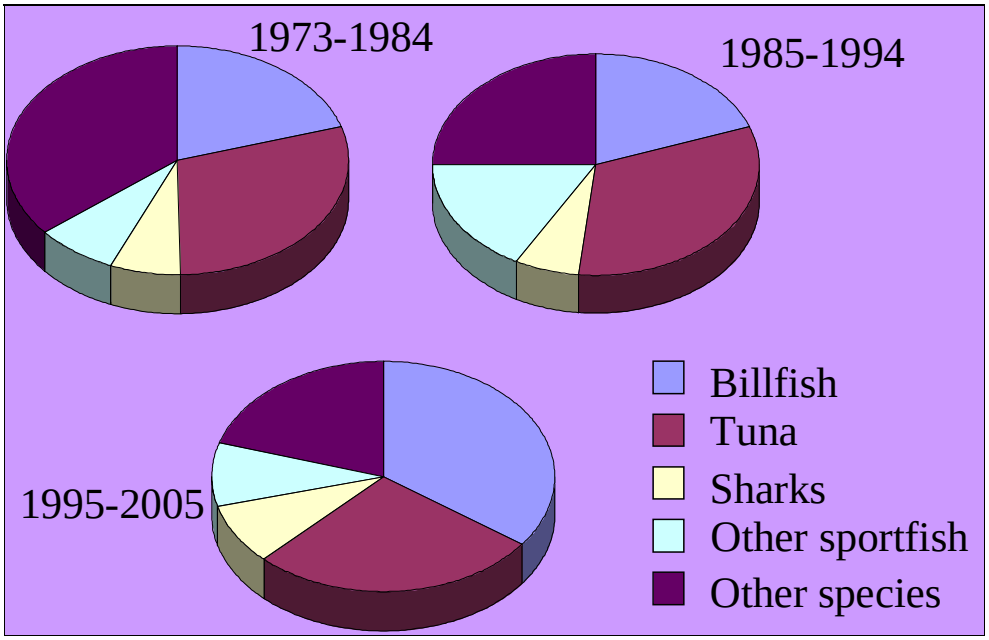
Figure 4 illustrates well the changes in numbers of different tuna species tagged through time. In the early years of the program, striped, or skipjack tuna were tagged in greatest numbers, followed by two other small species, mackerel tuna and bonito. These were primarily targeted by sportfishing club members, who were active taggers in those early years. In the mid 1980s, anglers were specifically requested to tag yellowfin tuna in greater numbers to assist in a scientific studies being undertaken on the species off New South Wales. This resulted in a large increase in numbers of yellowfin being tagged in the mid to late 1980s, and has continued since then, albeit with availability of yellowfin tuna declining in the late 1990s. Albacore have also been an important species on the program, with most being tagged off southern NSW and Tasmania during winter months. There have been declines in numbers of both yellowfin and albacore tagged since the late 1990s compared with averages for most of that decade.

Figure 5. Numbers of each major shark species tagged each year



Here we can see that whaler sharks (a mixed group consisting of at least ten species) have dominated the shark species tagged for most of the past three decades, except for the early years of the program and a period in the late 1900s when mako sharks and blue sharks topped the tagging list for single years. It is interesting to note the broad peaks in tagged numbers of hammerheads (1990 to 1994), blue sharks (1995 to 2000) and makos (about 1995 to 2001), all of which declined since. This may be due to availability, but is more likely due to declining effort directed at sharks generally. This aspect warrants further analysis, in conjunction with the results of the ongoing Gamefish Monitoring Program, conducted by NSWDPI. We can consider long term trends in tagging of major species groups by lumping data by decades (Figure 6).

Figure 6. Proportions of main species groups tagged, by decade



The main changes indicated in this figure are a marked increase in the tagging of billfish since 1995 (compared with all other species combined), and a steady decline in the proportion of 'other species' tagged (this category includes species such as silver trevally, tailor and snapper). The proportions of tunas and sharks tagged each decade have remained remarkably consistent.

Recapture information

One of the main motivations for tagging fish is curiosity, in particular, to answer the question: where might this fish go after I release it? Before discussing movements of tagged fish, we consider here recapture rates for the program, that is, the proportion of fish tagged which are subsequently recaptured (or, at least, reported as recaptures). The likelihood of recapturing (and reporting) a tagged fish depends on many factors, including mortality, dispersal rates, intensity of fishing, tag loss rate and, of course, the reporting of a tag by whoever finds it on the released fish.

The number of fish recaptured for the program stood at 6,029 in July 2005, which represents an overall reported recapture rate 2.0% of all fish tagged. Figures 7 and 8 show the broad range

of recapture rates recorded over the duration of the program. Some recapture rates of particular interest are 6.9% for both yellowtail and Australian salmon, 6.6% for gummy sharks and 3.3% for southern bluefin tuna. A surprising 2.1% of yellowfin tuna have been recaptured, but less than 1% of black marlin, and 1.1% of sailfish have been recaptured. The low recapture rates of some species such as billfish leads to some speculation that mortality after release must be very high. However, there are many reasons to be confident that this is not necessarily the case, not least of which is an overall high survival rate of billfish, as shown by electronic tagging of these species around the world.

Figure 7. Reported recapture rates of gamefish species greater than 2 percent

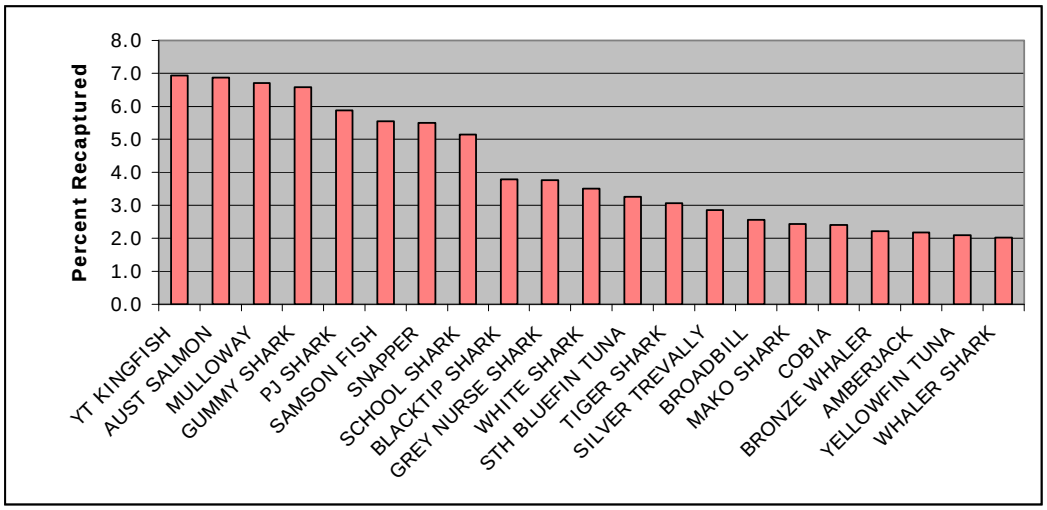
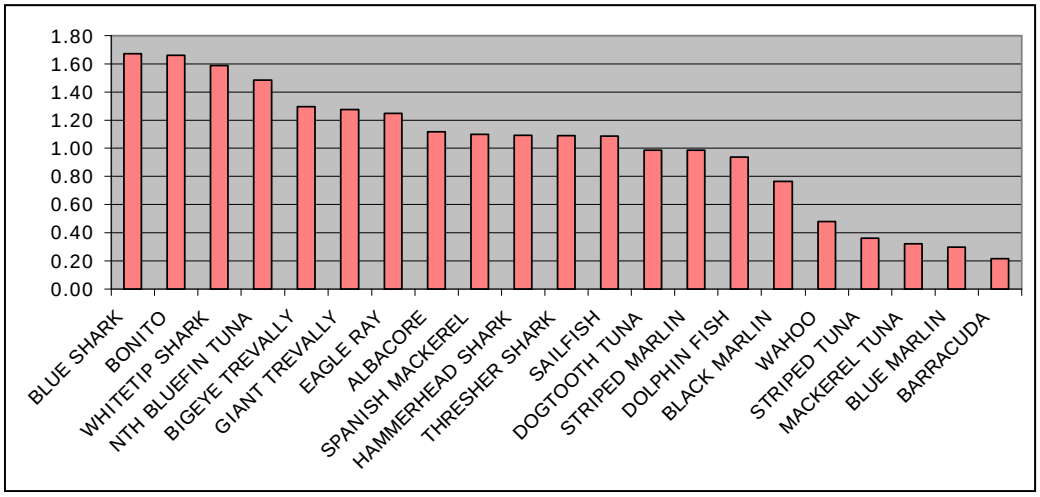


Figure 8. Reported recapture rates of gamefish species less than 2 percent



Obviously there is insufficient space to provide an in depth analysis of movements of all species as revealed by the tagging program. However, the tables below list some of the distance and time-at-liberty records accumulated over the years. It should be noted that the maximum distances moved and maximum times at liberty are usually not for the same fish.

Table 2. Record distances moved by tagged fish

Species	Max Distance Moved (km)
Black marlin	14,426
Southern bluefin tuna	14,334
Blue marlin	10,200
Yellowfin tuna	6,750
Blue shark	5,350
Mako shark	4,755
White shark	4,124
Dolphin fish	3,354
Albacore	3,145
Yellowtail kingfish	3,000
NB Spanish mackerel	2,474
Striped marlin	1,980
Striped tuna	1,913
Bronze whaler	1,005
Tiger shark	730
Sailfish	500
Samson fish	413

Table 3. Record times at liberty by tagged fish

Species	Max Time at Liberty
Mako shark	11 yrs 363 days
Bronze whaler	11 yrs 123 days
Yellowfin tuna	7 yrs 120 days
Black marlin	7 yrs 75 days
Albacore	7 yrs 10 days
Tiger shark	6 yrs 344 days
Australian salmon	6 yrs 323 days
Samson fish	6 yrs 239 days
NB Spanish mackerel	5 yrs 120 days
Amberjack	4 yrs 143 days
Sailfish	4 yrs 169 days
Yellowtail kingfish	3 yrs 268 days
Bronze whaler	3 yrs 232 days
Blue marlin	3 yrs 73 days
Gummy shark	3 yrs 16 days
Southern bluefin tuna	3 yrs 4 days
Striped marlin	2 yr 267 days
White shark	2 yrs 145 days
Blue shark	2 yrs 144 days
Hammerhead shark	2 yrs 93 days
Bonito	1 yr 222 days
Giant trevally	361 days
Qld spotted mackerel	335 days
Dolphin fish	241 days

Of course, these record setting recaptures are only the tip of the iceberg, and they can be somewhat misleading. For example, the blue marlin listed in the tables is one of only a handful which have so far been recaptured on the Australian program, and could well be the exception rather than the rule. On the other hand, many black marlin have moved distances of well over 3,000 km, and the average distance travelled by recaptured black marlin (after allowing time for dispersal) is greater than 1,200 km! Similarly, while there have been several long distance movements recorded for yellowtail kingfish, the great majority of the 1,900 plus recaptures have been made near their points of release, even after several years. This characteristic is also true for sailfish, with very few Australian tagged sailfish moving more than 100 km. A final observation from Table 3 is of interest: dolphin fish have never been recaptured after more than eight months at liberty. This could well be because they disperse quickly into non-fishing areas, but the main reason is simply because the species has a very short life span, making the chances of recapture less and less likely through time.

Having shown these impressive records, and stressed that these are the exceptions to the rule, it is important to note that tagging studies derive other important information by

determining average rates and distances of dispersal. This information greatly assists scientists in defining the 'stocks' of a particular species, that is, the limits or boundaries of self-contained pop-ulations within the whole range and distribution of a species. In the case of many game fishes, their distributions are vast - as great as any animal on earth. Blue marlin, yellowfin and bigeye tuna, for example, occur throughout the tropic and temperate zones of the three major global oceans, while black and striped marlin range right across the Pacific and Indian Oceans. Are there sub-populations within these ranges, or do individual fish mix and breed freely throughout? This is a critical question for international management of these fishes, and this is exactly where the gamefish tagging program is playing a crucial role. Consider for example, long distance movements of the three species of marlin in the Pacific.

Plotting all long distance movements shows that black marlin disperse over a very wide area, while striped marlin don't appear to be so highly mobile. Crossings of the equator by billfish are rare, but do occur, and while black marlin appear capable of trans-Pacific crossings, all of the available recapture results for striped marlin indicate that they do not make such journeys. There probably haven't been sufficient blue marlin recaptures yet to make generalizations, although as noted above, at least one blue marlin moved from the Pacific to the Indian ocean. (And let's not forget that every piece of information mentioned so far is the result of recreational anglers voluntarily releasing their fish as part of this great experiment).

Armed with the results of all of this tagging, parallel genetic studies have been undertaken which may also be able to delineate stock structure of the billfishes. For example, DNA fingerprinting of striped marlin has revealed that there are almost certainly three separate populations of this widespread marlin in the Pacific (samples collected from east coast tournaments greatly assisted this study). Tagging had suggested that this might be the case, so here we have a good example of two methods working hand in hand to resolve a major issue in international fisheries.

Highlights by Species

There have been many interesting recaptures over the past 5 years or so. The following represent just some of these. Also presented are some summary data for the whole program on distances moved against times at liberty for selected species.

Black marlin

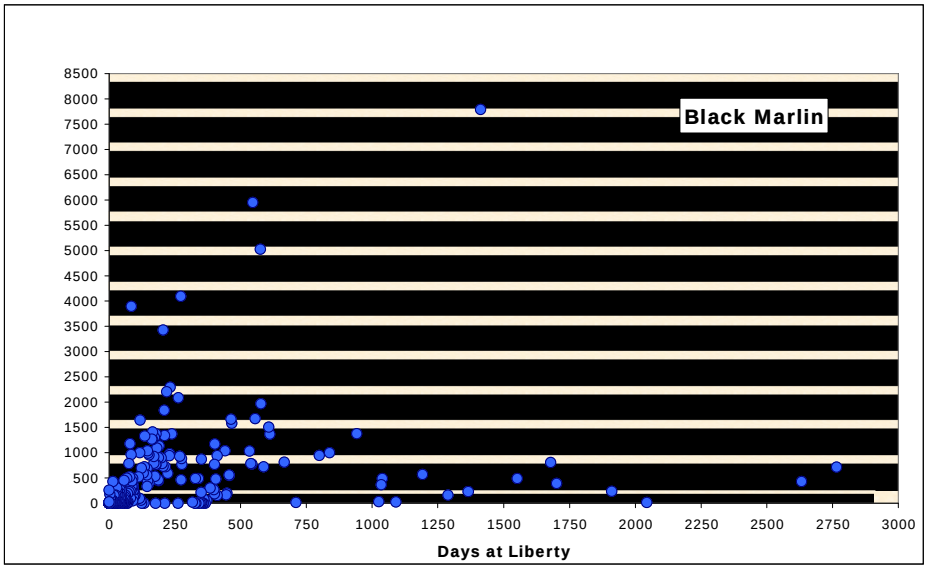
There have been 41,146 black marlin tagged and 314 recaptures reported. In the past four years, there have been about 7,000 tagged and 105 recaptures, or 1.5%. This represents a large increase in percent recapture for this species. Two highlights are of considerable interest.

A black marlin was recaptured after a record 2,766 days (7 years six months) of liberty. This fish was tagged on 18 September 1996 off Townsville at an estimated weight of 25kg. It was recaptured on 15 April 2004 at Lindenhaufen on the southern coast of the island of New Britain, PNG. It weighed only 108kg, and may therefore have been a male fish (it was not sexed).

This long term recapture narrowly surpassed the time at liberty record for black marlin tagged on the

program. That was held by a 20kg fish which was tagged at 9 mile reef off Tweed Heads in November 1993. It was recaptured in February 2001 after 7 years and three months off Brush Island in southern New South Wales. Of note in both of these cases is that the tagged marlin were recaptured and reported by recreational anglers. Figures 9 (not shown) and 10 demonstrate that black marlin is perhaps the most highly mobile of any of the species tagged on the program. Figure 9 shows movements of long distance travelling black marlin, noting also those that extend 'off the page'. These results indicate that black marlin mix freely throughout the tropical to temperate Pacific, although relatively few recaptures have occurred in the northern hemisphere (ie, while some fish have crossed the equator, they are the exceptions to the rule).

Figure 10. Plot of distance moved (NM) against time at liberty for all recaptured black marlin



Striped marlin

The number of striped marlin tagged on the program continued to increase, the total now standing at just under 14,000 fish. Recaptures have been reported at a rate of just under 1%, translating to a total of 137 recaptures reported. Results of tagging striped marlin to date present a good example of contrasting behaviour of different species of closely related fish. In this case, both the extent of movement and the times at liberty of tagged striped marlin contrast markedly with those of black marlin.

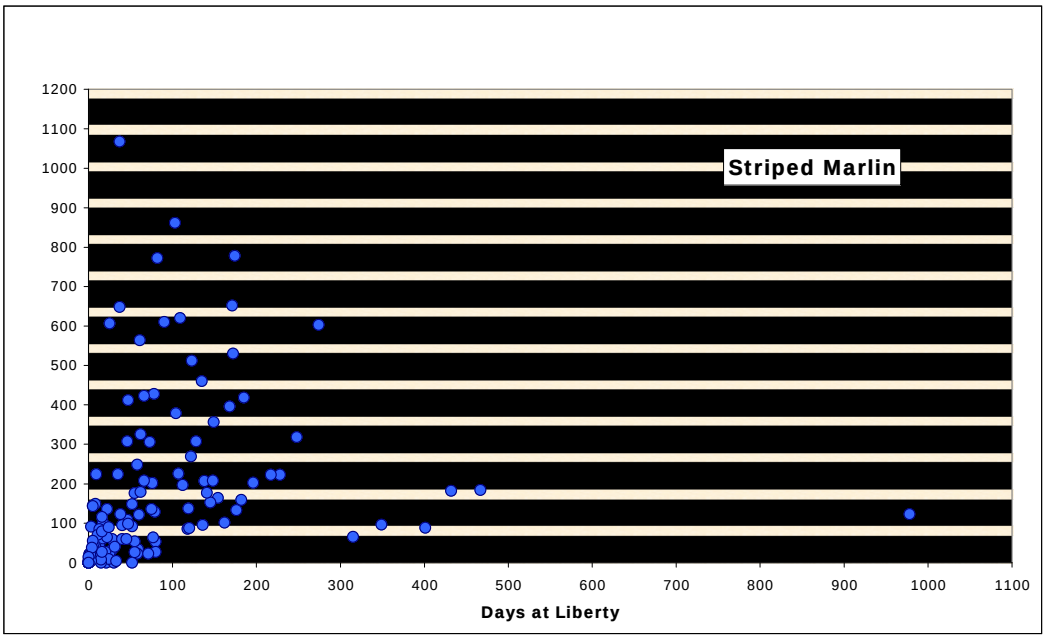
The longest time at liberty for a tagged striped marlin was set by a fish tagged at Bermagui NSW and recaptured off Wollongong two years and 248 days after release. This is much longer than any other of the other 136 recaptures for striped marlin. In fact, only three other striped marlin have been recaptured more than one year after release. This contrasts markedly with results for black marlin, many of which have been recaptured after a year or more, extending to well over 7 years for a recent recapture (see above).

As mentioned, distances moved by tagged striped marlin tend to be quite restricted. In fact, the longest movement of a striped marlin recorded on the program so far is only 1,067 nautical miles, from Bermagui to the Coral Sea, about half way between Townsville and Vanuatu. The interesting point about this recapture

was that the time at liberty was only 37 days, indicating an average rate of travel of 29 nautical miles (53 km) per day. It is stressed that this is an exception to the rule for striped marlin, which, on average, moved at relatively slow rates.

Figure 12 plots all striped marlin recaptures to date and further illustrates this general lack of long distance movements for this species, at least by those tagged off eastern Australia. More than 90% of recaptures have occurred within 500 nautical miles of the release points, while more than 95% of recaptures have occurred within 300 days of release.

Figure 12. Distance moved (NM) against days at liberty for all striped marlin recaptures



Blue marlin

There have been 3,694 blue marlin tagged, but only 11 recaptures reported to date. Blue marlin are tagged in lower numbers than black or striped marlin, so it is not surprising that recaptures of tagged blues are relatively uncommon.

Distances moved by blue marlin have varied enormously. One famous recapture some years ago of a fish tagged north of Sydney and recaptured south of Sri Lanka demonstrated that this species was even capable of moving between oceans. In contrast, a blue marlin tagged in January 1998 off Port Macquarie, NSW and recaptured off the Gold Coast Seaway (QLD) in March 2001 showing a minimum movement of only 218 nautical miles during its 38 months at liberty.

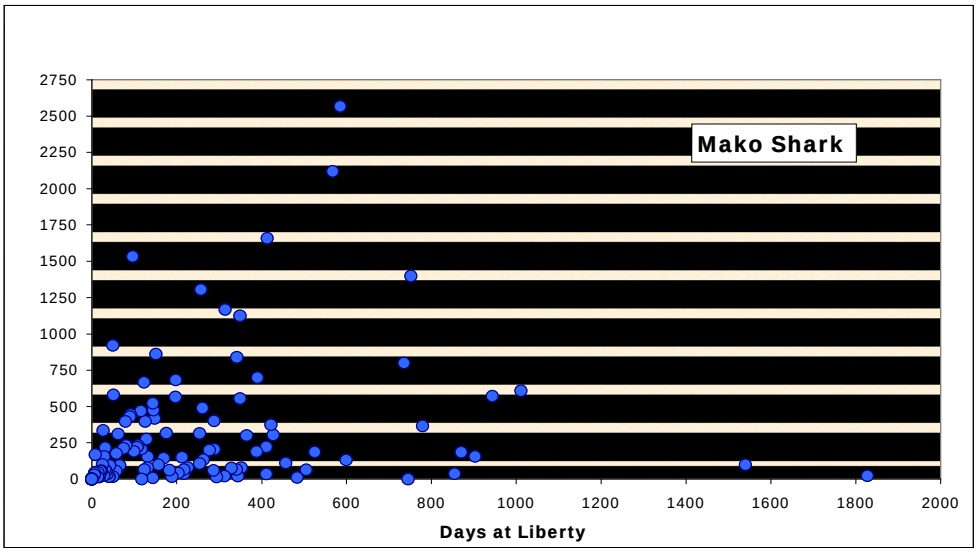
In the last several years, blue marlin tagged in widely separated locales have been recaptured. A blue marlin tagged off Vanuatu was recaptured off Fiji, about 590 miles to the north, after 727 days (almost exactly 2 years). Another, tagged off Lae, Papua New Guinea was recaptured off Noosa, QLD, after 6 months while a third blue marlin tagged off Perth was recaptured 23 days later in the same area.

Mako sharks

In terms of numbers tagged, the mako shark is the most important shark species tagged on the program. A total of 5,534 makos had been tagged to the end of 2004/05 and 134 recaptures had been reported. The furthest distance moved by a tagged mako shark to date is 2,577 nautical miles by a shark tagged off Geroa NSW in February 2003 and recaptured in the Philippines 585 days later.

A mako shark also holds the record for time at liberty. This was a shark tagged off Port Macquarie, NSW in September 1987 and recaptured off Port Hacking NSW, just 180 miles to the south, after 4,375 days, or just short of 12 years. Other makos have moved substantial distances. A small mako, estimated at 50kg at recapture, was tagged off Plymouth New Zealand and recaptured 752 days later off Lake Macquarie, NSW.

Figure 13. Plot of distance moved (NM) against time at liberty for all recaptured mako sharks



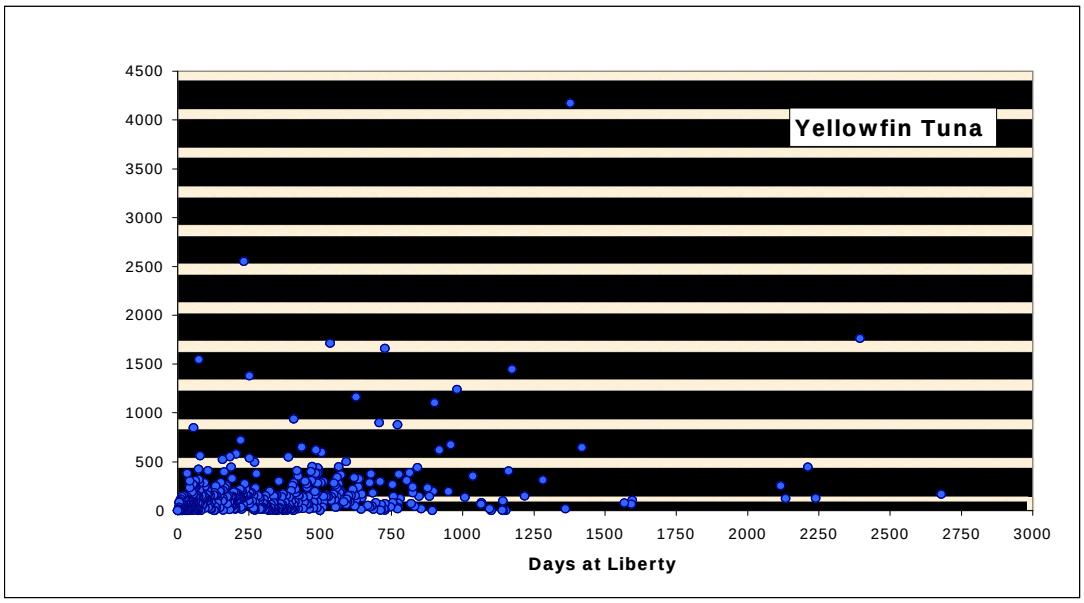
Yellowtail kingfish

Since the origins of the tagging program, yellowtail kingfish have continued to show the highest recapture rate of any species which has been tagged in large numbers. The total tagged to date stands at 27,891, of which a substantial 1,937 have been recaptured, or 6.94% of all kingfish tagged. Over the past five years, 372 kingfish have been recaptured and as in previous years, the results clearly show that this is one species which tends to move very little. Of those 372 recaptures, only 20, or 5.4%, moved more than 100 nautical miles, even though the average time at liberty was 168 days. To further illustrate the lack of movement, 86.3% of recaptured fish were caught within 50 miles of their release locations. The one fish which did move a substantial distance (760 miles) was also at liberty for the longest period. That kingfish was tagged off Kangaroo Island (SA) in April 2002 and recaptured off Jervis Bay NSW in December 2005. During its 3 years 9 months of liberty, it had grown from an estimated 3kg to 11.5kg.

Yellowfin tuna

There have been 29,275 yellowfin tuna tagged and 615 recaptures reported. This recapture rate of 2.1% over the entire duration of the program is high compared with other so called highly migratory fishes (billfish and other tunas) and reflects the fact that yellowfin have a tendency to remain near the continental shelf on the east coast for extended periods, where they are susceptible to capture by both recreational and commercial fisheries. To emphasise this point, over the past five years, 48 tagged yellowfin tuna have been recaptured, 47 of which were caught within 400 nautical miles of their release locations, and 42 within 250 miles. These fish had been at liberty for between one and 2,239 days, with an average of 445 days (the fish at liberty for 2,239 days had only move an apparent 126 miles). The one fish which moved further than 400 miles was a real exception to the rule. This fish was tagged at the Batemans Bay (NSW) canyons and recaptured 1173 days (3 years 2 months) later off the Solomon Islands, a distance of 1,447 nautical miles.

Figure 14. Plot of distance moved (NM) against time at liberty for all recaptured yellowfin tuna



Albacore

Tagging of albacore by recreational anglers on the program has provided unexpected benefits. To date, over 13,800 albacore have been tagged and 154 recaptures reported. Many of these have been at liberty for long periods, and while some have moved long distances, others have been recaptured near their points of release after years. Of five recent recaptures of tagged albacore, three had been at liberty for extensive periods. All had been tagged off Bermagui NSW. The first was recaptured 1,410 days (3 years 10 months) later off Vanuatu. The second was recaptured after 1,884 days (5 years 2 months) off New Zealand while the third was recaptured only about 200 miles to the east, but after a time at liberty of 2,567 days, or just over 7 years! That fish was tagged in June 1997 at an estimated size of 10kg. Upon recapture by a Japanese longline vessel in June 2004, it weighed 25kg, thereby adding more evidence for the slow growth rate attributed to this species.

Sailfish

Sailfish have been tagged in large numbers and continue to demonstrate that they are not a highly migratory species. Overall, 20,800 sailfish have been tagged and 226 recaptured, 39 of those in the past five years. The recaptured sailfish had mainly been tagged off Mooloolooba in southeast Queensland, as well as several off Broome and Dampier in Western Australia. Of the 39 cases of recaptured sailfish, all but two were recaptured within 50 miles of their release points, most considerably less, even after periods at liberty of up to 897 days. The two exceptions had not moved great distances either, with one travelling an apparent 88 miles along the Great Barrier Reef after 514 days while the second moved 106 miles (Sandy Cape to Barwon Banks QLD) in 13 days.

White shark

Given their low population size, it is not surprising that white sharks have never been tagged in large numbers on the program. Since the program began, there have been 286 white sharks tagged, and only 10 recaptured, most of which have been short term and indicating little movement. However, one shark free tagged by a CSIRO scientist at Neptune Islands in South Australia in August 1999 made its way to the North Island of New Zealand (2,227 nautical miles to the east) where it was recaptured by a commercial fisherman. The shark had been at liberty for 2 years 4 months and during that time had apparently grown from a modest 350cm (approximately 550kg) to a huge 549cm and a weight of 1200kg.

Note: This species has been removed from the recommended species for tagging list.

Tiger Shark

Relatively few tiger sharks have been tagged (717) and recaptured (22). One significant recapture however was recorded during the period covered by this report. This was a tiger shark tagged off Broken Bay NSW in January 1996, and estimated to weigh 120kg at the time. The shark was subsequently recaptured in December 2002, off Swansea NSW, only 30 miles to the north. During its record 7 years 11 months at liberty, it had grown to 236kg indicating a relatively moderate growth rate. Of course, it may well have travelled much further and returned, but as has been the case for all other 21 recaptured tiger sharks, was tagged and recaptured on the continental shelf of the southeast coast.

Dolphin Fish

The Program has yielded important results about dolphinfish, particularly as the species is regularly targeted around NSW DPI Fish Aggregating Devices (FADs). There have been over 18,500 dolphin fish tagged and 175 recaptured. Of those recaptures, some 70% were made at the points of release near Fish Aggregating Devices (FADs) or other buoys. The remaining recaptures indicated mainly short coastal movements (ie, north or south), but some as far as 500km. The exception to this rule, and the furthest distance moved between release and recapture for an Australian tagged dolphin was a remarkable 1,810 nautical miles

(3,350km) after 241 days at liberty. This fish was tagged off Port Stephens at a size of only 40cm and recaptured at Fiji weighing 9.8kg. This lack of long distance movements, especially offshore, is in direct contrast with results from the eastern US. There, 156 fish have been recaptured, and while many were also short term recaptures, the average time at liberty has been 40 days and average distance moved, an impressive 281 miles (520km). One fish travelled 137 miles (254km) in a single day! Lastly, of tagged fish which moved away from the coast, the average distance travelled was a staggering 1,560 miles (2,890km). These are remarkable results, perhaps indicating the amount of fishing for dolphinfish throughout the Caribbean (and therefore the chances of recaptures) compared with the situation off eastern Australia.

Typical sized dolphinfish about to be released off NSW. (photo Phil Bolton)

Interpreting Tag-Recapture Information

In analysing results of this and any other tagging programs, various factors need to be taken into account to avoid possible biases in the way the data are interpreted. For example, when considering maps depicting movements of tagged fish (eg, Figures 9 & 11), it should be remembered that not only do the longest movements nearly always represent a small proportion of all of the recaptures, but also that the points of recapture are entirely dependent on where and when fishing activity was taking place at the time. After all, tagged fish won't be recaptured in a particular area if there is no fishing there (we call this 'fishery dependent bias'). The effect of this bias is that, while we might build up a good picture of tagged fish moving to various locations based on them being caught in those places, we don't know whether or not tagged fish are also moving to areas where little or no fishing is occurring. In other words, it cannot be assumed that the movement patterns shown by such recaptures are the only movements which fish are making. Another fishery dependent aspect of tagging programs is relying on fishers not only to find tags, but also to report them. Fishers may not report tags for a whole variety of reasons, both intentional and unintentional. Again, non reporting bias can lead to misinterpretation of tag-recapture data.

Yet another point to consider is that tagging tends to take place in convenient locations where gamefish anglers can readily fish for, and tag numbers of particular species. For example, the tagging of adult black marlin is always concentrated off the Great Barrier Reef while juvenile black marlin are tagged at specific locations along the east coast (Townsville, southeastern Queensland and the cental New South Wales coast). Recaptures of fish tagged at such sites will naturally tend to show movement away from these tagging 'windows', often resembling a star-burst pattern (that is, all fish moving away from a central location). Ideally, fish should be tagged at as many locations as possible within the distributional range of the species, but of course in practice, this is often not possible to achieve.

Popup Satellite Tags

The issues outlined above have presented continuing challenges for conventional tagging programs, but with the development of popup satellite archival tags (PSATs), we are now able to gain some insights into fishery independent movements of tagged fish. PSAT tags are really mini computers which continuously record data on depth of the fish, surrounding water temperature and ambient light. If the fish is near the surface, the latter provides the times of sunrise and sunset, which is unique for any given longitude on the Earth's surface. After a predetermined time period (normally 3 to 6 months) the tag releases itself from the fish and floats to the surface, whereupon it transmits all of its on-board data to passing ARGOS satellites. Of course, fish still need to be caught to be tagged, but once tagged, the PSAT tag will reveal the movements of the fish completely independent of where and when fishing is taking place. The downside of PSAT tags is that they are very expensive, but given the considerable benefits of their use, investment in this technology is well worth while. Over the past several years, nearly 100 marlin (blue, black and striped) have been tagged with PSAT tags off eastern Australia. Funding for this work has come from a variety of sources including CSIRO, the Game Fishing Association of Australia, Research & Development Foundation and the US based Offield Center for Billfish Studies. The results of this ongoing tagging effort have proven very useful in interpreting conventional tagging results and in planning for future PSAT tagging operations. As

well, the NSW Saltwater Recreational Fishing Trust is currently funding a project to tag ten tiger sharks off New South Wales using PSAT tags to determine the seasonal movements of this important target species. It is to be hoped that the use of this technology will continue to grow, in parallel with the conventional Gamefish Tagging Program, with both methods complementing each other in providing valuable information on pelagic fishes into the future.

Reporting a Tagged Fish

If you catch a fish that is already tagged and you can clearly read the tag in position, you may release the fish after having carefully recorded the tag number. Ensure that you record the capture details immediately after release. If the tag is difficult to read, cut off the old tag and if possible, re-tag the fish with a new tag. Tags that look old or are covered in marine growth indicate that the fish is likely to have been at large for a long time and these long-term recaptures are particularly valuable to the program.

Please ensure that you accurately record the tag number, species, method of capture, location and GPS co-ordinates, date, estimated size (or actual if landed) and condition of fish on release. Report the details as soon as possible. If you decide to take the fish, please carefully record and report the capture information as above. NSW DPI will provide details of the time and distance the fish has travelled and its growth to the anglers who first tagged the fish and later recaptured it.

One other point regarding reporting recaptures of tagged fish should be kept in mind. In these days of nearly 100% release of billfish, previously tagged fish are quite often caught and re-released without being able to retrieve the earlier tag. If you do hook and release a fish which has a previous tag in place, you should definitely record the details (even though the tag number is unknown) and report the incident to NSW DPI (Fisheries) at Cronulla as a genuine recapture. In this way, better statistics on actual recapture rates of billfish will be able to be maintained.

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