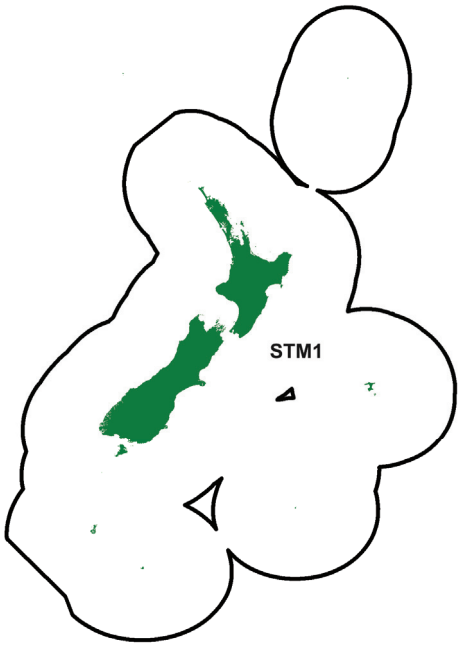
STRIPED MARLIN (STM)

(*Kajikia audax*)



1. FISHERY SUMMARY

Management of the striped marlin and other highly migratory pelagic species throughout the western and central Pacific Ocean (WCPO) will be the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). Under this regional convention, New Zealand will be responsible for ensuring that the fisheries management measures applied within New Zealand fisheries waters are compatible with those of the Commission.

At its third annual meeting (2006) the WCPFC passed a Conservation and Management Measure (CMM) (this is a binding measure that all parties must abide by) relating to conservation and management of striped marlin in the southwest Pacific Ocean (http://www.wcpfc.int). This measure restricts the number of vessels a state can have targeting striped marlin on the high seas.

1.1 Commercial fisheries

Most of the commercial striped marlin catch in the southwest Pacific is caught in the tuna surface longline fishery, which started in 1952 and in the New Zealand region in 1956. Since 1980 foreign fishing vessels had to obtain a license to fish in New Zealand's EEZ and were required to provide records of catch and effort. New Zealand domestic vessels commenced fishing with surface longlines in 1989 and the number of vessels and fishing effort expanded rapidly during the 1990s. Also in 1989, licences were issued to charter up to five surface longline vessels (Japanese) to fish on behalf of New Zealand companies. Very few striped marlin are caught by other commercial methods, although there are occasional reports of striped marlin caught in purse seine nets, however, these fish are seldom seen in catch records.

A three-year billfish moratorium was introduced in October 1987 in response to concerns over the decline in availability of striped marlin to recreational fishers. The moratorium prohibited access to the Auckland Fisheries Management Area (AFMA - Tirua Point to Cape Runaway) by foreign licensed and chartered tuna longline vessels between 1 October and 31 May each year. Licence restrictions required that all billfish, including broadbill swordfish, caught in the AFMA be released. In 1990 the moratorium was renewed for a further 3 years with some amended conditions and it was reviewed and extended in 1993 for a further year.

Regulations prohibited domestic commercial fishing vessels from retaining billfish caught within the AFMA since 1988. In 1991 these regulations were amended to allow the retention of broadbill swordfish and prohibited the retention of marlin species (striped, blue and black marlin) by commercial fishermen in the entire EEZ of New Zealand. These regulations and government policy changes on the access rights of foreign licensed surface longline vessels have replaced the billfish moratorium. A billfish memorandum of understanding (MOU) between representatives of commercial fishers and recreational interests provided a framework for discussion and agreement on billfish management measures. This MOU was reviewed annually between 1990 and 1997, and was last signed in 1996.

Estimates of total landings (commercial and recreational) for New Zealand are given in Table 1. Commercial catch of striped marlin reported on Catch Effort Landing Returns (CELRs) and Tuna Longline Catch and Effort Reports (TLCERs) and recreational catches from New Zealand Big Game Fishing Council records are given in Table 1. Figure 1 shows historical landings and longline fishing effort for the STM stocks.

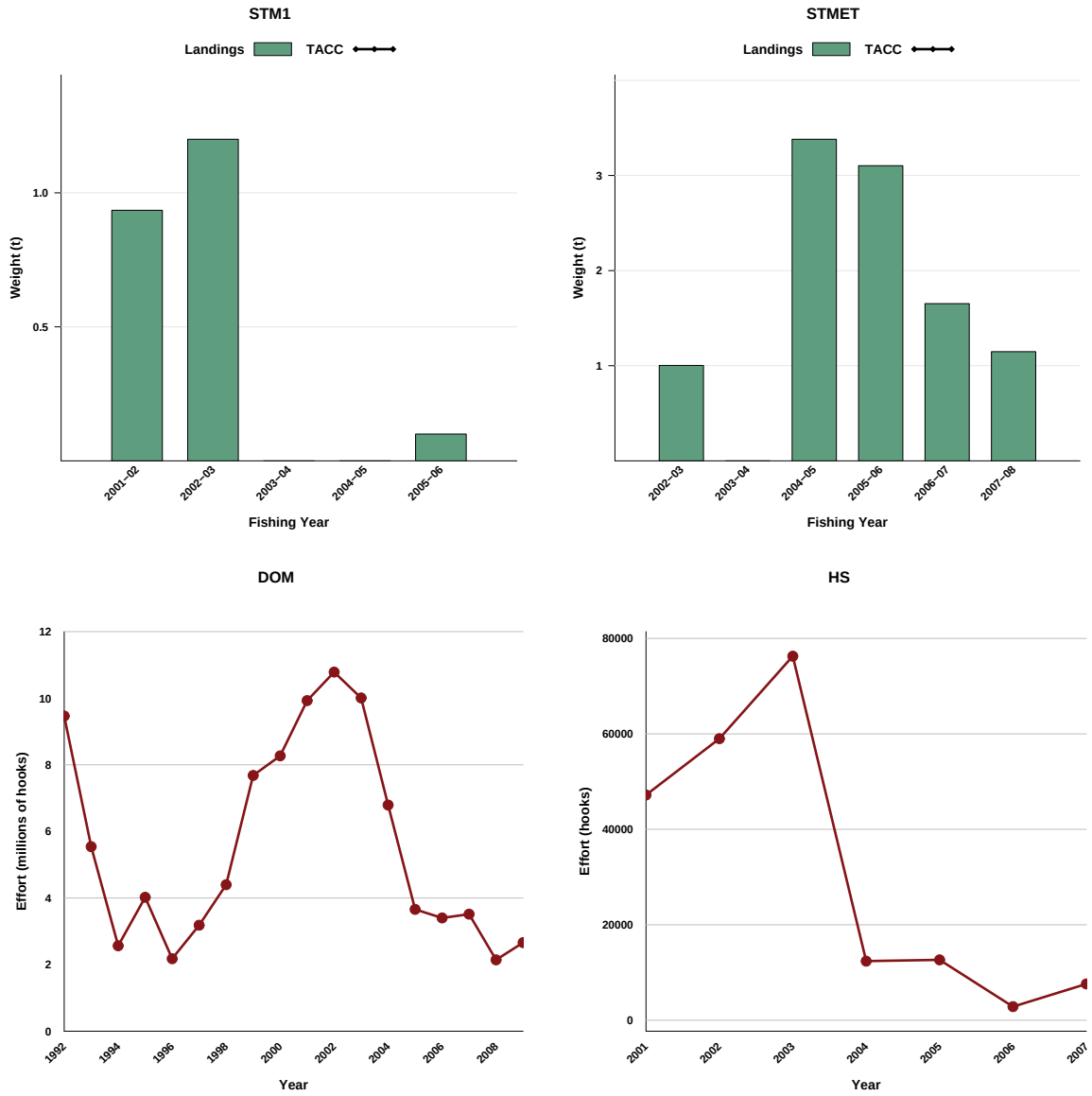


Figure 1: [Top] Striped marlin catch from 2001-02 to 2005-06 within NZ waters (STM1), and 2002-03 to 2007-08 on the high seas (STMET). [Bottom] Fishing effort (number of hooks set) for all domestic and high seas surface longline vessels, from 1992 to 2009 and 2001 to 2007, respectively.

Table 1: Commercial landings and discards (number of fish) of striped marlin in the New Zealand EEZ reported by fishing nation (CELRs and TLCERs), and recreational landings and number of fish tagged, by fishing year.

Fishing	Japan	Japan	Korea	Philippine	Domestic	NZ Recreational		Total
Year	Landed	Discarded	Landed	Discarded	Discarded	Landed	Tagged	
1979-80	659					692	17	1 368
1980-81	1 663		46			792	2	2 503
1981-82	2 796		44			704	11	3 555
1982-83	973		32			702	6	1 713
1983-84	1 172		199			543	9	1 923
1984-85	548		160			262		970
1985-86	1 503		19			395	2	1 919
1986-87	1 925		26			226	2	2 179
1987-88	197		100			281	136	714
1988-89	23		30		5	647	408	1 113
1989-90	138				1	463	367	969
1990-91		1			6	532	232	771
1991-92		17			1	519	242	779
1992-93					7	608	386	1 001
1993-94					59	663	929	1 651
1994-95					182	910	1 206	2 298
1995-96					456	705	1 104	2 265
1996-97					441	619	1 302	2 362
1997-98					445	543	898	1 886
1998-99					1 642	823	1 541	4 006
1999-00		2			798	398	791	1 989
2000-01					527	422	851	1 800
2001-02					225	430	771	1 426
2002-03		3		7	205	495	671	1 381
2003-04		1			423	592	1051	2 067
2004-05					258	834	1345	2 437
2005-06					168	630	878	1 676
2006-07					154	675	963	1 792
2007-08						469	785	1 254

Total recorded commercial catch was highest in 1981–82 at 2843 fish and 198 t. Following the introduction of the billfish regulations, striped marlin caught on commercial vessels were required to be returned to the sea and few of these fish were recorded on catch/effort returns. In 1995 the Ministry of Fisheries instructed that commercially caught marlin be recorded on TLCERs. However, compliance with this requirement was inconsistent and estimated catches in the tuna longline fishery (calculated by scaling-up observed catches to the entire fleet) are considerably higher in all fishing years for which these estimates are available (since 1994–95). However, these estimates are imprecise and probably biased, as the MFish Observer Programme coverage of the domestic fleet has been low and has not adequately covered the spatial and temporal distribution of the fishery.

Very few striped marlin in the TLCER database were reported south of 42°S and most striped marlin reported by commercial fishers were caught north of 38°S. Historically, Japanese and Korean vessels caught most striped marlin between 31°S and 35°S with a peak at 33°S. The New Zealand domestic fleet caught the majority of their striped marlin in the Bay of Plenty, East Cape area, between 36°S and 37°S.

A significant number of records from domestic commercial vessels provide the number of fish caught but not estimated catch weight. The total weight of striped marlin caught per season was calculated using fisher estimates from TLCER and CELR records plus an estimate from the number of fish with blank weights multiplied by the mean recreational striped marlin weight for that season. Catch has been split by landed fish and discarded or tagged for inside the New Zealand EEZ and outside the EEZ (Table 2).

Table 2: Reported total New Zealand landings and discards (commercial and recreational) (t) and commercial landings from the southwest Pacific Ocean (t) of striped marlin from 1991 to 2007.

	Commercial Landed	Commercial Discarded	Recreational Landed	Recreational Tagged	EEZ Total	NZ Commercial Outside the EEZ	SWPO Landings
1991	0.1	0.5	52	21	73		1 941
1992	0.8	0.1	57.8	21.9	81		1 969
1993	0	0.8	62.8	34.4	99		2 388
1994		5.7	66.3	81.2	153		2 729
1995		17.2	95	100	214	0.1	2 512
1996		42.3	70.6	91.6	204	0.9	1 972
1997		42.9	64.4	127.8	230	0.2	1 892
1998		42.7	56.5	80.9	182	2.2	2 980
1999		161.9	73.2	130.9	345	0.4	2 408
2000		74.1	40.9	72.1	179	0.7	1 907
2001		51.6	45.5	78.7	177	1.7	1 986
2002		21.2	45.8	76.9	144	0.9	2 355
2003		21.1	54.6	65.4	142		2 759
2004		41.7	62.7	105.6	208		2 364
2005		22.3	87.9	127.3	237	4.1	1 858
2006	0.4	16.3	62.2	83.5	162	3.2	1 878
2007	1.2	15.8	66.2	92.4	174	1.7	
2008			45.1	75.4			

Source: TLCER and CELRs; NZBGFC and Holdsworth (2008a); SCTB Working paper SWG-3-IP-2.

Combined landings from within New Zealand fisheries waters are relatively small compared to commercial landings from the greater stock in the southwest Pacific Ocean (8% average for 2002-2006). In New Zealand, striped marlin are landed almost exclusively by the recreational sector, but there are no current estimates of recreational catch from elsewhere in the southwest Pacific.

1.2 Recreational fisheries

The striped marlin fishery is an important component of the recreational fishery and tourist industry from late December to May in northern New Zealand. There are approximately 100 recreational charter boats that derive part of their income from marlin fishing and a growing number of private vessels participating in the fishery. Many of the largest fishing clubs in New Zealand target gamefish and are affiliated to the national body, the NZ Big Game Fishing Council (NZBGFC). Clubs provide facilities to weigh fish and keep catch records.

In 1988 the NZBGFC proposed a voluntary minimum size of 90 kg for striped marlin in order to encourage tag and release. Fish under this size do not count for club or national contests or trophies but most are included in the catch records each fishing season (1 July to 30 June). In 2007–08 the 59 recreational fishing clubs affiliated to NZBGFC reported landing 3686 billfish, sharks, kingfish, mahimahi, and tuna, and tagged and released a further 2065 gamefish. Of these, 485 striped marlin were landed and weighed in 2007–08 (13% of landed fish in NZBGFC records) and the number tagged was 751 (36% of tagged fish in NZBGFC records). There is a fairly complete historical database of recreational catch records for each striped marlin caught by the Bay of Islands Swordfish Club and the Whangaroa Big Game Fishing Club going back to the 1920s, when this fishery started.

1.3 Customary non-commercial fisheries

Maori traditionally ate a wide variety of seafood, however, no record of specific marlin fishing methods has been found to date. An estimate of the current customary catch is not available.

1.4 Illegal catch

There is no known illegal catch of striped marlin.

1.5 Other sources of mortality

Some fish that break free from commercial or recreational fishing gear may die due to hook damage or entanglement in trailing line. A high proportion of fish that are caught are released alive by both commercial and recreational fishers. Data collected by the Ministry of Fisheries Observer Services

from the tuna longline fishery suggest that most striped marlin are alive on retrieval (72% of the observed catch). The proportion of striped marlin brought to the boat alive was similar on domestic longliners and foreign and charter vessels. However, post release survival rates are unknown.

Recreational anglers tag and release 65% of their striped marlin catch (mean of the last ten years). Most of these fish are caught on lures. Reported results from 66 pop-up satellite archival tags (PSATs) deployed on lure caught striped marlin in New Zealand showed a high survival rate following catch and release. The pop-up archival tags are programmed to release from the fish following death. No fish died and sank to the seafloor. One fish was eaten (tag and all) by a Lamnid shark about 15 hours after it was tagged and released. A small proportion of other PSAT tags failed to report so the fate of these fish is unknown.

Striped marlin caught on baits in Mexico showed a 26% mortality rate within 5 days of release. Injury was a clear predictor of mortality; 100% of fish that were bleeding from the gill cavity died, 63% of fish hooked deep died, and 9% of those released in good condition died.

2. BIOLOGY

Striped marlin is one of eight species of billfish in the family Istiophoridae. They are epi-pelagic predators in the tropical, subtropical, and temperate pelagic ecosystem of the Pacific and Indian Oceans. Juveniles generally stay in warmer waters of the range, while adults move into higher latitudes and temperate water feeding grounds in summer (southern hemisphere 1st quarter of the calendar year; 3rd quarter in the northern hemisphere). The latitudinal range estimated from longline data extends from 45^{o}N to 40^{o}S in the Pacific and from continental Asia to 45^{o}S in the Indian Ocean. Striped marlin are not uniformly distributed, having a number of areas of high abundance. Tagged individuals have undergone extensive seasonal migrations.

Samples from recreationally caught striped marlin in New Zealand indicate the most frequent prey items are saury and arrow squid, followed by jack mackerel. However, 28 fish and 4 cephalopod species have been identified from stomach contents indicating opportunistic feeding also occurs.

The highest striped marlin catch for the surface longline method is recorded in January-February but striped marlin have been caught in New Zealand fisheries waters in every month, with lowest catches in November and December.

Striped marlin are oviparous and are known to spawn in the Coral Sea between Australia and New Caledonia. Their ovaries start to mature in this region during late September or early October. Spawning peaks in November and December and 60-70% of fish captured at this time are in spawning condition. The minimum size of mature fish in the Coral Sea is recorded at approximately 170 cm lower jaw-fork length (LJFL) and 36 kg. Striped marlin captured in New Zealand are rarely less than 200 cm (LJFL) suggesting that these fish are all mature. Female striped marlin on average, are larger than males but sexual dimorphism is not as marked as that seen in blue and black marlin. The sex ratio of striped marlin sampled from the recreational fishery in Northland (n = 61) was 1:1 prior to the introduction of the voluntary minimum size (90 kg). There is no clear evidence of striped marlin reproductive activity in New Zealand waters. The northern edge of the EEZ around the Kermadec Islands extends into subtropical waters. According to historical longline records, in some years, there are moderate numbers of striped marlin in this area from October to December. Therefore, striped marlin spawning could occur in this area.

Unvalidated age and growth estimates are available for striped marlin in New Zealand waters. These estimates were derived from counts of opaque growth zones in thin sections of the third dorsal spine with the assumption that one opaque zone is formed per year. Work is underway to confirm this using marginal increment analysis. Growth bands for New Zealand striped marlin that are between 2 and 8 bands are broadly comparable with overseas studies. Melo-Barrera et al. (2003) identified between 2 and 11 bands in Mexico, and Skillman and Yong (1976) classified up to 12 age groups from length

frequency analysis of striped marlin in Hawaii. Recreational catch records kept by the International Game Fish Association (IGFA) list the heaviest striped marlin as 224.1 kg caught in New Zealand in 1975.

Estimates of biological parameters for striped marlin in New Zealand waters are given in Table 3.

Table 3: Estimates of biological parameters.

Fishstock	Estimate			Source
1. Natural mortality (M)				
STM	0.49–1.33			Boggs (1989)
STM	0.389–0.818			Hinton & Bayliff (2002)
2. Weight = a (length)^b (Weight in kg, length in mm lower jaw fork length)				
	a	b		
STM males	2.0×10^{-8}	2.88	New Zealand	Kopf et al. (2005)
STM females	2.0×10^{-8}	2.90		
3. Von Bertalanffy model parameter estimates				
	k	t_0	L_∞	
STM	0.22	-0.04	3010	New Zealand Kopf et al. (2005)
STM	0.23	-1.6	2210	Mexico Melo-Barrera et al (2003)
STM male	0.315–0.417	-0.521	2774-3144	Hawaii Skillman & Yong (1976)
STM female	0.686–0.709	0.136	2887-3262	Hawaii Skillman & Yong (1976)

3. STOCKS AND AREAS

Striped marlin are a highly migratory species, and fish caught in the New Zealand fisheries waters are part of a wider stock. The stock structure of striped marlin in the Pacific Ocean is not well known, but the focus of current research activities. The two most frequently considered hypotheses are: (1) a single-unit stock in the Pacific, which is supported by the continuous "horseshoe-shaped" distribution of striped marlin; and (2) a two-stock structure, with the stocks separated roughly at the Equator, albeit with some intermixing in the eastern Pacific.

Spawning occurs in water warmer than 24°C, mainly in November and December, in the southern hemisphere. Known spawning areas in the southwest Pacific are in the Coral Sea in the west and French Polynesia in the east of the region. The southern hemisphere spawning season is out of phase with the north Pacific. Very warm equatorial water in the western Pacific, where striped marlin are seldom caught, may be acting as a natural barrier to stock mixing. However, in the eastern Pacific striped marlin may be found in equatorial waters and 3 fish tagged in the northern hemisphere have been recaptured in the southern hemisphere. The results of mitochondrial DNA analysis are consistent with shallow population structuring within striped marlin in the Pacific.

The New Zealand Cooperative Gamefish Tagging Programme has tagged and released 16 878 striped marlin between 1 July 1975 and 30 June 2008. Of the 78 recaptures reported 30 have been made outside the EEZ spread across the region from French Polynesia (142°W) to eastern Australia (154°E) and from 2°S to 38°S latitude. There have been no reports of striped marlin tagged in the southwestern Pacific being recaptured elsewhere in the Pacific Ocean. Projects by New Zealand and US researchers using electronic tags will reveal new information on the movement and habitat preferences of Pacific striped marlin.

Striped marlin are believed to have a preference for sea surface temperatures of 20 to 25°C. Generally striped marlin arrive in New Zealand fisheries waters in January and February, and tag recaptures indicate that they leave the New Zealand EEZ between March and June; although they have been caught by surface longliners in the EEZ in every month. Within the EEZ most striped marlin are caught in FMA 1, FMA 9, and FMA 10.

4. STOCK ASSESSMENT

With the establishment of WCPFC in 2004, the Scientific Committee of the Western and Central Pacific Fisheries Commission (WCPFC) will review stock assessments of striped marlin in the western and central Pacific Ocean stock. Unlike the assessment for the main tuna stocks, billfish assessments will not be undertaken by the Oceanic Fisheries Programme of Secretariat of the Pacific Community (SPC) under contract to WCPFC, at least in the early years of the Commission. As the status of billfish stocks was recognised as important to the Commission, it was recommended that members of the WCPFC collaborate on billfish assessments.

In 2006, scientists from Australia and the Secretariat of the Pacific Community (SPC) collaborated on an assessment for striped marlin in the southwest Pacific Ocean (further details can be found in Langley et al. (2006)). This was the first attempt to carry out an assessment for this stock and further improvements of the methods used are expected for future assessments. It was noted that the results should be considered preliminary as there remains significant uncertainty regarding the most important parameters of the model. In the absence of other assessments for this stock the following two paragraphs were developed by the WCPFC Scientific Committee on the basis of the results of the preliminary assessment:

> "Several of the plausible model scenarios investigated indicate that current levels of fishing mortality may approximate or exceed the reference level F_{MSY} and current spawning biomass levels may approximate or be below the biomass based reference point B_{MSY}.
>
> On the basis of this preliminary assessment, it is recommended as a precautionary measure that there should be no increase in fishing mortality (i.e. fishing effort) on striped marlin in the southwestern Pacific. This recommendation applies particularly to the area encompassing the Coral Sea and the Tasman Sea as these fisheries account for most of the striped marlin catch in the southwest Pacific."

4.1 Biomass and yield estimates

No estimates of biomass or yield are available for New Zealand. A southwestern Pacific stock assessment is currently underway.

4.2 Other factors

Given that New Zealand fishers encounter some of the largest, and likely oldest striped marlin in the Pacific, the abundance of fish found within New Zealand fisheries waters will be very sensitive to the status of the stock. In addition environmental factors may also influence availability. The average size of striped marlin in the recreational fishery has changed over the last 80 years. Individual weights were averaged from publish catch records in club year books (Figure 2).

A commercial marlin fishery was started in waters north of New Zealand in 1956 by Japanese surface longline vessels. Mean fish weight has declined since then and there is more inter annual variability. There have been changes to recreational fishing methods the area fished over this time. The most significant change was in the late 1980s when a switch from trolled baits to artificial lures. Over the last 15 years more than half the weights have been estimated following tag and release.

For 32 years annual postal surveys collected striped marlin catch and effort information by east Northland gamefish charter boats. This gave an average catch per vessel day fished over the whole season. Survey responses were trimmed to include vessels with 6 or more years data and a range of factors were investigated using GLMs. Year, vessel and port were the factors selected. Results are plotted in Figure 2 with a mean of 0 and s.d. of 1. Club catch tallies and charter catch rates had been low in the 1960s and early 1970s (Holdsworth *et al.* 2003). Good charter CPUE in the late 1970s and early 1980s were followed by three very poor years (Figure 3). Since then there has been an increasing trend in charter CPUE. While these data are informative on recreational fishing success in east Northland care should be taken making more general assumptions because of the relatively small area where this fishery operates.

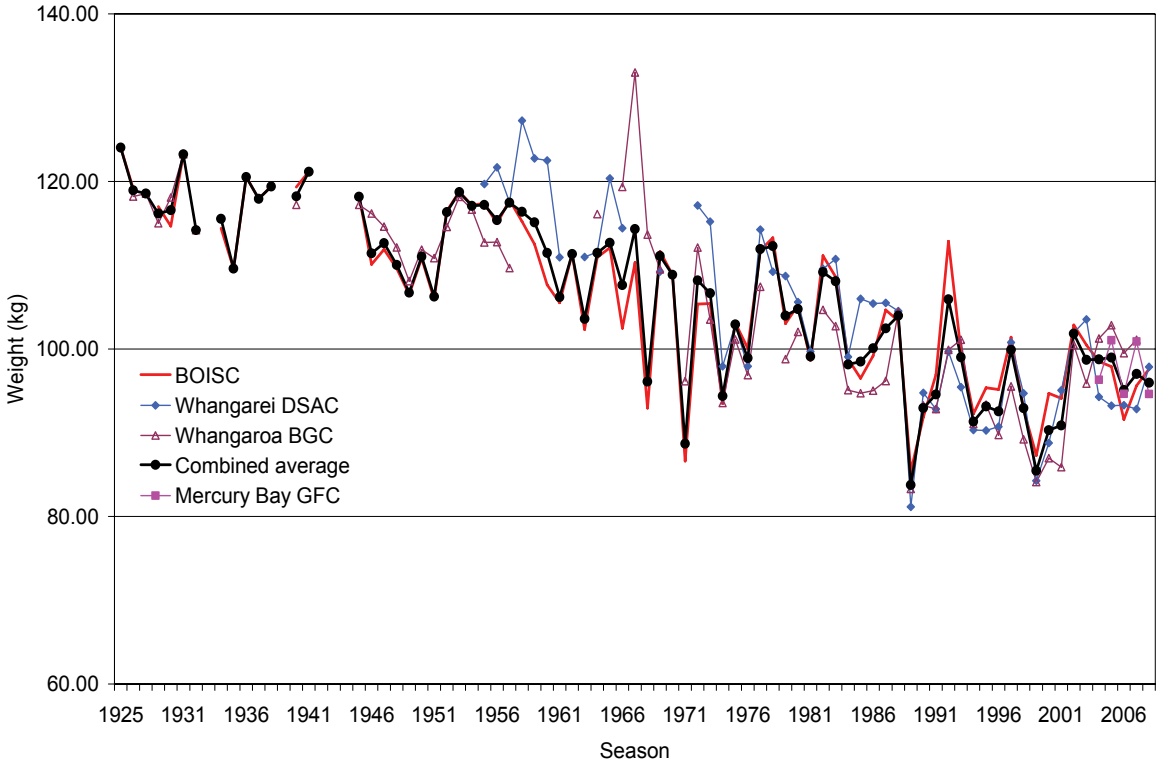


Figure 2: The mean weight of striped marlin caught by recreational fishers by season, by club, and the combined mean (black), (BOISC is Bay of Island Swordfish Club).

In 2006–07 the Ministry of Fisheries instigated a billfish logbook programme to capture fine scale temporal and spatial information along with marlin catch and effort. Data collection expanded to include private vessels in all areas, including Bay of Plenty, West coast North Island and the Three Kings. In the first year 37 usable vessel data sets were collected representing 16% of the reported annual recreational catch (NZ Big Game Fishing Council Records). In 2007–08 data was collected from 47 logbooks representing 25 % of the reported recreational catch.

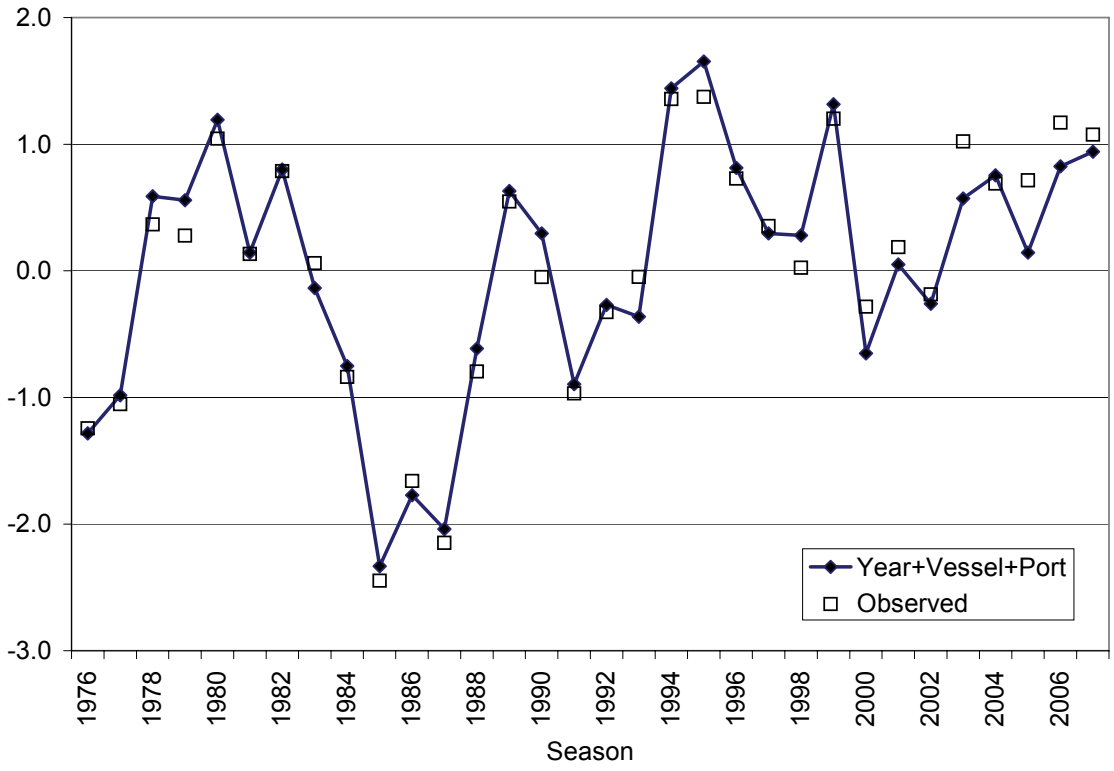


Figure 3: Standardised east Northland recreational striped marlin catch per charter boat day fished by season.

5. STATUS OF THE STOCK

Stock structure assumptions
Western and Central Pacific Ocean
All biomass in this Table refer to spawning biomass (SB)

Stock Status	
Year of Most Recent Assessment	A preliminary stock assessment was conducted in 2006
Assessment Runs Presented	
Reference Points	Target: $SB>SB_{MSY}$ and $F<F_{MSY}$ Soft Limit: Not established by WCPFC Hard Limit: Not established by WCPFC
Status in relation to Target	About as Likely as Not that $SB<SB_{MSY}$ and About as Likely as Not that $F>F_{MSY}$
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unknown
Historical Stock Status Trajectory and Current Status	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	
Recent Trend in Fishing Mortality or Proxy	
Other Abundance Indices	
Trends in Other Relevant Indicator or Variables	

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch causing decline below limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	Level 1: Quantitative Stock assessment	
Assessment Method		
Main data inputs		
Period of Assessment	Latest assessment: 2006	Next assessment: ?
Changes to Model Structure and Assumptions		
Major Sources of Uncertainty		

Qualifying Comments

Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 30°S. Seabird bycatch mitigation measures are required in the New Zealand, Australian EEZ's and through the WCPFC Conservation and Management Measure (CMM2007-04). Sea turtles also get incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure (CMM2008-03). Shark bycatch is common in longline fisheries and largely unavoidable; this is being managed through New Zealand domestic legislation and to some extent through Conservation and Management Measure (CMM2008-06).

6. FOR FURTHER INFORMATION

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