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Final Research Report for
Ministry of Fisheries Research Project ENV2000/03
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Report Title	A review of literature relevant to the assessment of the stock status of striped marlin and Ray's bream in New Zealand
Author	M. P. Francis and L. H. Griggs
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7. Executive Summary

Striped marlin

Striped marlin (*Tetrapturus audax*) are found throughout the tropical, subtropical and temperate Pacific and Indian Oceans, and also occasionally in the South Atlantic. They live in the upper mixed layer, and are caught mainly as bycatch on commercial tuna longlines and by recreational fishers. Striped marlin appear to grow rapidly, but the ageing methods have not been validated. Length at maturity is about 140–160 cm eye-fork length. Longevity and the natural mortality rate are unknown.

Striped marlin tagged in New Zealand have been recaptured from Australia to the Tuamotu Islands. The stock fished in New Zealand probably ranges at least throughout the southwest Pacific Ocean, and possibly through most of the South Pacific Ocean. It is not known whether the stock also ranges into the North Pacific, but the lack of trans-equatorial tag recaptures, and the existence of genetic differences, suggest this is unlikely. Therefore stock status, and the impact of New Zealand catches on the stock, must consider data from a large geographic area. Unfortunately, little relevant information exists for this purpose. Furthermore, the availability of marlins in the New Zealand Exclusive Economic Zone (EEZ) is influenced by climatic factors.

Commercial catches in the western and central Pacific declined from around 40 000 t per annum in the 1960s to around 15 000 t through the 1980s and 1990s. There was a decline in catch per unit effort (CPUE) from 1.8 fish per 1000 hooks in the late 1960s to around 0.4 in the late 1970s, and it has remained at that level ever since. These estimates may encompass more than one stock. The declines are at least partly attributable to a shift by tuna longline vessels to targeting bigeye tuna in depths greater than those usually inhabited by striped marlin, and possibly also the establishment of EEZs around many Pacific Ocean nations. No CPUE analyses have been carried out for New Zealand waters.

Recent New Zealand catches cannot be accurately determined, but were probably less than 600 t per year. This represents only a few percent of the total annual catch from the western and central Pacific (but a considerably higher proportion of the catch from the region south of the Equator). Actual fishing mortality would be lower, because most striped marlin are released by recreational and commercial fishers (though the survival rate of released marlin is unknown). Nevertheless, New Zealand catches are probably rising as the tuna longline fishery expands: there has been a four-fold increase in domestic fishing effort in the last four years, and most of that effort has been deployed in the northern North Island waters inhabited by striped marlin.

The impact of New Zealand's tuna longline catches on the stock of striped marlin that is available in New Zealand waters cannot be determined without better information on (a) stock range; (b) the extent of fishing removals from the whole stock (including better estimates of the recent catches made by the New Zealand tuna longline and purse seine fisheries, and commercial fisheries outside New Zealand); and (c) an index of stock relative abundance.

Ray's bream

Ray's bream (*Brama brama*) are found in the North Atlantic Ocean and throughout subtropical to subantarctic waters of the Southern Hemisphere. They are replaced in the North Pacific Ocean by Pacific pomfret (*Brama japonica*). Ray's bream are caught throughout New Zealand, but they are most abundant around the southern South Island. Nothing is known about the stock structure, seasonal patterns of abundance, migratory behaviour or stock size of Ray's bream in New Zealand. Based on what is known about Ray's bream from the North Atlantic and South Pacific, and about Pacific pomfret, New Zealand Ray's bream probably undergo seasonal migrations (southward in summer), with larger fish penetrating further into high latitudes than smaller fish. There is currently insufficient information to determine whether there is more than one stock in the South Pacific.

Most Ray's bream caught by tuna longliners are 40–60 cm fork length, and are probably mature (female maturity occurs at about 43 cm). Fish caught by trawlers tend to be smaller and are probably immature. Nothing is known about spawning, growth rate, mortality rate, age at maturity, or longevity of Ray's bream in New Zealand. However, by analogy with Ray's bream from the North Atlantic, and Pacific pomfret, it is likely that New Zealand fish have high growth and natural mortality rates and moderate longevity.

Recent New Zealand landings of Ray's bream average about 500 t per year, with most coming from trawl fisheries. Most of the trawl catch appears to be landed. Only about 10 t per year are caught by tuna longline fisheries, and most is discarded. There is no information on Ray's bream catches from anywhere else in the South Pacific. Given the small size of the tuna longline catch, the impact of that fishery on the stock is probably negligible. The impact of the trawl fishery on the stock cannot be determined.

8. Objectives

3. To undertake a literature review of the stock status of striped marlin (*Tetrapturus audax*) and Ray's bream (*Brama brama*).

The rationale for this objective in the Ministry of Fisheries' tender document stated: "This review should allow an assessment to be made as to how great an impact the current catch level in tuna longline fisheries may have on striped marlin and Ray's bream in New Zealand waters." Such an assessment would ideally be carried out by developing a population model for each species, but that is impossible with the currently available information, and is obviously outside the scope of the present project. In this study, we focussed on reviewing the currently available information that may be relevant to the future development of population models and assessment of the stocks of striped marlin and Ray's bream that are fished in New Zealand. Because both species show evidence of long range migrations, and therefore large stock ranges, information from both New Zealand and elsewhere in the Pacific Ocean was reviewed. Information on Ray's bream from the North Atlantic was also included where appropriate.

9. Methods

A literature review was carried out for striped marlin and Ray's bream in order to compile information that is relevant to an assessment of their stock status in New Zealand. Relevant information includes stock structure and range, growth rate, natural mortality rate, age at maturity and recruitment to the fishery, total stock catch, New Zealand catch by both longline and other fishing methods, and stock size indices such as catch per unit effort (CPUE). This information was obtained from the primary and secondary literature (including unpublished reports), and from unpublished data.

10. Results

The results of the literature review are presented separately for striped marlin and Ray's bream below.

Striped marlin (*Tetrapturus audax*)

Distribution

Striped marlin are billfish of the Family Istiophoridae. They have a wide distribution, occurring mainly in the tropical, subtropical and temperate waters of the Pacific and Indian Oceans, but they are occasionally found on the Atlantic side of the Cape of Good Hope (Nakamura 1985). The latitudinal range limits, based on commercial longline fishery data, extend from about 45° N in the North Pacific to 30° S in the eastern South Pacific and 45° S in the western South Pacific. In the Indian Ocean they range from the northern margin to 45° S in the southwest and 35° S in the southeast (Nakamura 1985).

Striped marlin are epipelagic and oceanic. They usually swim above the thermocline, and inhabit the isothermic surface layer at all stages of the life cycle (Nakamura 1985). They are usually found between the 20 °C and 28 °C surface isotherms (Whitelaw 2001). Striped marlin occur in cooler water than other marlins (Nakamura 1985), and are rarely found in shallow coastal waters (Williams n. d.). Juveniles occur in the same open water habitat as the adults, but appear to stay in warmer waters and only move to higher latitudes after reaching maturity (Whitelaw 2001). Small striped marlin occur in equatorial waters of the Pacific, but they are absent from latitudes 5–16° S. In 15–30° S, longitudinal stratification is apparent with larger fish occurring in the western Pacific (Nakamura 1985).

Striped marlin may be the shallowest swimming of all marlins as indicated by the proportion of fish caught on the shallowest hooks of longlines (Hanamoto 1979). Boggs (1992) found that most striped marlin are caught at depths less than 120 m, and suggested that eliminating shallow hooks could substantially reduce the bycatch of striped marlin without reducing fishing efficiency for large tunas such as bigeye. Brill et al. (1993) found that striped marlin spend more than 85% of their time in the mixed layer, above 90 m depth. The maximum depth for striped marlin appears to be determined by temperatures 8 °C colder than the mixed layer, rather than an absolute lower temperature (Brill et al. 1993).

Movements and stock structure

Striped marlin undergo extensive migrations from their breeding grounds in the subtropics to feeding grounds in temperate waters during summer (Nakamura 1985). Tagging shows that some striped marlin move long distances, especially those tagged in New Zealand (Holdsworth & Saul 1998; Davies & Hartill 1998; Hartill & Davies 1999, 2000, 2001). Fish tagged in northern New Zealand have been recaptured in Australia and the central Pacific, including Fiji, Western Samoa, Marquesas Islands, and Tuamotu Islands. Fish tagged in the northeast Pacific showed few long-range migrations, and no trans-Pacific migrations (Squire 1987). Tagging studies throughout the Pacific suggest that there is no mixing between the southwest and northeast Pacific (Squire 1987; Whitelaw 2001).

Graves & McDowell (1994) analysed mitochondrial DNA from striped marlin from four different locations in the Pacific, and found significant spatial partitioning of genetic variation. Samples taken from the same location in different years suggested temporal stability. This indicates that there may be several stocks in the Pacific and that striped marlin exhibit smaller-scale population structure than do Pacific tunas. Innes et al. (1998) also found intraspecific variation in striped marlin. Graves & McDowell (1994) suggested that there could be spawning site fidelity, and that international management of striped marlin must focus on smaller, genetically homogeneous stocks in order to preserve genetic variation. Since striped marlin tagged in New Zealand have been observed to disperse throughout the southwest and south-central Pacific, it appears that the stock being exploited in New Zealand waters should be managed on at least that spatial scale, and possibly at the scale of the entire South Pacific Ocean.

Pacific Ocean catch and catch per unit effort

The commercial catch of striped marlin is taken mostly by surface longlining, with harpooning making up about 1% of the catch (Nakamura 1985). Striped marlin are caught throughout the Pacific, with high catches in the northwest and central northern Pacific, east central Pacific, and southwest Pacific off the east coast of Australia (Carocci & Majkowski 1996; Whitelaw 2001). Most of the catch is taken by Japan (Whitelaw 2001).

Striped marlin are sometimes targeted in longline fisheries, but are taken mostly as bycatch. Striped marlin are the tenth-most recorded species in longline catches (Secretariat of the Pacific Community database) and comprise around 1% of the catch by number (Whitelaw 2001). Striped marlin is one of the principal billfish species caught in Australian waters, and is important to both the commercial and recreational sectors (Campbell et al. 1996).

The catch of striped marlin reported by longliners from the SPC statistical reporting area (most islands and enclosed high seas in the western and central Pacific Ocean, excluding Hawaii) has decreased from around 40 000 t per annum in the 1960s to around 15 000 t through the 1980s and 1990s (SPC database). CPUE in the same area declined from a high of 1.8 fish per 1000 hooks in the late 1960s to around 0.4 in the late 1970s, and has remained at that level ever since (Whitelaw 2001). These declines in catch and CPUE are at least partly attributable to a shift by tuna longline vessels to targeting bigeye tuna (*Thunnus obesus*) in depths greater than those usually inhabited by striped marlin. The establishment of Exclusive Economic Zones (EEZs) around many Pacific Ocean nations may also have restricted the intensity of high seas fisheries.

The area immediately north of New Zealand (10–35° S in the western subtropical Pacific), supports the highest catch rates in the western Pacific (Bailey et al. 1996) and is a likely source of many of New Zealand's striped marlin. CPUE there has steadily declined since the 1960's (Bailey et al. 1996), but again, this may be due to causes other than reduction in stock size.

Striped marlin in New Zealand

Striped marlin is the main marlin species caught by tuna longliners and recreational fishers in the New Zealand EEZ (Francis et al. 1999; 2000; 2001). Many of the recreationally caught striped marlin are tagged and released (Holdsworth & Saul 1998; Davies & Hartill 1998; Hartill & Davies 1999, 2001; Table 1). The numbers of striped marlin reported caught by recreational gamefishers peaked at 2349 in 1998–99, and then declined to about half that level in 1999–00.

Table 1: Numbers of striped marlin tagged and released, and caught, by recreational fishers and the tuna longline fishery. Recreational data are for July–June years, tuna longline data for fishing years (October–September). –, no data.

	Recreational fishery		Tuna longline fishery	
Year	Tagged and released[1]	Reported caught[1]	Reported caught[2]	Estimated caught[3]
1989–90	365	–	–	–
1990–91	229	–	21	–
1991–92	241	–	17	–
1992–93	386	–	7	–
1993–94	929	–	63	–
1994–95	1 206	–	150	–
1995–96	1 104	–	422	–
1996–97	1 300	1 796	355	570
1997–98	898	1 414	467	945
1998–99	1 544	2 349	1 651	–
1999–00	790	1 188	806	–

Sources:
1 Davies & Hartill (1998); Hartill & Davies (1999; 2000; 2001)
2 TLCERs (see Francis et al. 2001)
3 Francis et al. (1999, 2000)

Tuna longline catches of striped marlin occur north of 38° S on the west coast North Island and north of 40° S on the east coast North Island. Most fish are caught off the continental shelf between the 1000 and 4000 m depth contours (Francis et al. 1999). Most (98%) fish are caught in December–July. Striped marlin tend to be caught when sea surface temperature exceeds 18 °C and fish is the main bait used (Francis et al. 2000).

Retention of commercially caught billfish was banned by a moratorium established in October 1987 to prevent competition with growing recreational fisheries. Commercially caught marlins must be returned to the sea dead or alive. In 1980–87, before the introduction of the moratorium, the mean annual striped marlin catch reported by longline fishers was 1459 fish (Francis et al. 2000). After the moratorium, some commercial fishers continued recording discarded striped marlin on their fishing returns, so the reported catches did not decline to zero, even though the landings did. Reporting became mandatory in 1996–97. Reported catches peaked at 1651 in 1998–99 and then declined by about half in 1999–00 (Table 1), thus paralleling the pattern seen in recreational catches.

Scientific observer reports have been used to estimate the number of striped marlin caught in the New Zealand tuna longline fishery (Table 1). In 1996–97 the estimate was 570 (95% confidence range 370–792) and in 1997–98 it was 945 (95% range 801–1089). This latter number corresponds with a weight of about 70–100 t (Francis et al. 2000). The point estimates are substantially higher than the reported catches in the same years (Table 1), indicating that not all striped marlin were reported by commercial fishers. Low observer coverage of the tuna longline fishery in 1998–99 and 1999–2000 prevented any comparable estimates for those years (Francis et al. 2001).

Striped marlin is the dominant billfish species taken by New Zealand purse-seine fisheries (Bailey et al. 1996). Habib et al. (1982) presented catch and length data for 36 striped marlin caught in 31 purse seine sets in northern New Zealand between December 1975 and March 1981. Habib et al. (1982) also observed 18 black marlin, 21 blue marlin and 25 unidentified billfish over the same period. Striped marlin occurred in 1.8% of purse seine sets in 1976–82 (Bailey et al. 1996). Recent levels of fishing effort, and striped marlin catches in the purse seine fishery are unknown. Six purse seine vessels have operated in New Zealand waters in recent years, taking about 6000 t of skipjack tuna (*Katsuwonus pelamis*) annually (Murray et al. 2000).

Tuna longliners caught about 24% and 40% of the estimated total striped marlin catch (excluding purse seine catches) in 1996–97 and 1997–98 respectively (Table 1). The percentage taken by tuna longliners in 1998–99 and 1999–2000 is not known, because of the possibility of under-reporting of catches, and the low scientific observer coverage in those years. However, domestic tuna longline fishing effort in northern North Island, where almost all striped marlin are caught, increased four-fold from 1.5 million hooks in 1996–97 to 6.2 million hooks in 1999–2000 (Francis et al. 1999, 2001). It is therefore likely that tuna longline catches now exceed recreational catches.

Total New Zealand catches of striped marlin are around 2500–6000 fish per year, corresponding with a total weight of about 170–600 t per year. This represents about 1–4% of the annual striped marlin catch of about 15,000 t from the western and central Pacific in recent years. The numbers of striped marlin actually killed by New Zealand fisheries is less than this, because most recreationally-caught fish are tagged and released, and all commercially-caught fish are released. Scientific observer data show that 72% of 249 striped marlin caught by tuna longlines between 1992–93 and 1999–2000 were alive when brought to the boat (Francis et al. 2001).

Spawning and larval distribution

Striped marlin do not form schools, but several individuals of similar size are often seen together during the spawning season in November–December (Nakamura 1985, Bailey et al. 1996). The southern Coral Sea (western South Pacific) is an important spawning ground for striped marlin. The main fishing ground (20–30° S, 154–160° E (Hanamoto 1977a, b; 1978)) appears to coincide with the main spawning ground. Fish from the South Pacific spawning grounds are larger (180–200 cm eye-fork length) than those from the North Pacific (Nakamura 1985). Spawning has not been reported from New Zealand waters.

Most female marlins (sailfish, blue marlin, and white marlin) spawn up to four times during the spawning season, while males can probably spawn throughout the year (de Sylva & Breder 1997).

The lower temperature limiting the distribution of larvae is 24 °C in both the Pacific and Indian Oceans (Nakamura 1985). Larvae of striped marlin have been recorded from the western North Pacific, west of 180° between 10° N and 30° N, and from the central South Pacific, west of 130° W between 10° S and 30° S. Larvae are most abundant in early summer with peaks during May–June in the western North Pacific, and November–December in the central South Pacific (Nakamura 1985). Larvae are rarely found in equatorial waters (Nakamura 1985).

Age, growth and mortality

Skillman and Yong (1976) developed growth curves for Hawaiian striped marlin from length-frequency data. Males and females grow at about the same rate. Two-year old fish were estimated to be about 180 cm fork length or 23 kg and 3-year old fish were 215 cm (43 kg). Four-year old males were 227 cm (52 kg) and females were 235 cm (59 kg). (Skillman & Yong 1976, Kailola et al. 1993).

Radtke (1983) described some of the methods that have been used to try to age billfish and the difficulties encountered. Billfish otoliths are very small compared with the otoliths of other fishes. Davie & Hall (1990) assessed the age structure of striped marlin in New Zealand using dorsal and anal fin spines and otoliths. They found that dorsal spine band numbers were significantly correlated with weight and estimated that 3-year old fish weighed 93 kg, 5-year olds weighed 109 kg and 7-year olds 126 kg. If the differences between the New Zealand and Hawaiian studies are real, South Pacific striped marlin grow substantially faster than those in the North Pacific.

Size at first maturity is 140–160 cm *eye-fork* length in the Taiwan area (Nakamura 1985). The minimum size of spawning fish in the southern Coral sea was about 143 cm eye-fork length (Hanamoto 1977b).

There is no estimate of natural mortality rate for striped marlin (Whitelaw 2001).

Feeding

Striped marlin are carnivorous, non-selective feeders. They appear to feed more on epipelagic species than do other billfish and tunas (Nakamura 1985). Baker (1966) recorded two species of cephalopods and about 16 species of teleosts from the stomachs of New Zealand striped marlin, with the fish families Carangidae, Clupeidae and Scombridae predominating. In the Bay of Islands area, the most abundant prey of striped marlin were saury, squid, jack mackerel, and pilchards (Saul 1984). Bailey et al. (1996) reported strong feeding behaviour associated with spawning in the western South Pacific.

Conclusions

Striped marlin are highly migratory, and the stock fished in New Zealand probably ranges at least throughout the southwest Pacific Ocean, and possibly through most of the South Pacific Ocean. It is not known whether the stock also ranges into the North Pacific, but the lack of trans-equatorial tag recaptures, and the existence of genetic differences, suggest this is unlikely. The estimates of catches and CPUE for the entire western and central Pacific Ocean may encompass two or more stocks. Declining catches and CPUE in this region during the 1960s and 1970s may have resulted from changes in fishing practices in tuna longline fisheries; catches and CPUE have been relatively stable over the last two decades. No CPUE analyses have been carried out for New Zealand waters, and in any event, the availability of striped marlin in New Zealand is probably influenced by climatic factors.

Recent New Zealand catches cannot be accurately determined, but were probably less than 600 t per year. This represents only a few percent of the total annual catch from the western and central Pacific (but a considerably higher proportion of the catch from the region south of the Equator). Actual fishing mortality would be lower, because most striped marlin are released by recreational and commercial fishers (though the survival rate of released marlin is unknown). Nevertheless, New Zealand catches are probably rising as the tuna longline fishery expands: there has been a four-fold increase in domestic fishing effort in the last four years, and most of that effort has been deployed in the northern North Island waters inhabited by striped marlin.

The impact of New Zealand's tuna longline catches on the stock of striped marlin that is available in New Zealand waters cannot be determined without better information on (a) stock range; (b) the extent of removals from the whole stock (including better estimates of the recent catches made by the New Zealand tuna longline and purse seine fisheries, and commercial fisheries outside New Zealand); and (c) an index of stock relative abundance.

Ray's bream (*Brama brama*)

Distribution

Ray's bream are pomfrets of the family Bramidae. They have a wide distribution, being found in the North Atlantic Ocean and throughout the subtropical to subantarctic waters of the Southern Hemisphere. They are apparently absent from the North Pacific Ocean, where they are replaced by Pacific pomfret, *Brama japonica* (Mead & Haedrich 1965; Mead 1972).

Movements and stock structure

Nothing is known about the stock structure, seasonal patterns of abundance, or migratory behaviour of Ray's bream in New Zealand waters. However, we can infer some aspects of their biology and behaviour from studies on the same species in the North Atlantic and South Pacific, and from studies on Pacific pomfret in the North Pacific.

In the North Atlantic, a target commercial fishery off Spain catches Ray's bream on longlines set in depths of 100 m over seabed depths of almost 500 m (Mead & Haedrich 1965; Mead 1972). The fishery is seasonal but the timing varies spatially and among years (Mead & Haedrich 1965; Mead 1972; Rodriguez 1980). Fish migrate northwards as the water warms in summer (Mead & Haedrich 1965; Mead 1972). The movements and depth range of the species appear to be limited to temperatures above 10 °C (Mead & Haedrich 1965).

Brama species (probably *B. brama* and *B. australis* combined) are distributed across the whole South Pacific between New Zealand and Chile, but are most abundant west of 110° W (Yatsu 1995). Highest catch rates occur at 36–52° S, and there is evidence of a migration southwards in summer (Yatsu 1995).

In the North Pacific, northward migrations into subarctic waters of subadult and adult Pacific pomfret occur during summer, with their distribution limited to surface temperatures greater than about 8–10 °C (Shimazaki 1989; Pearcey et al. 1993; Savinykh 1994). Spatial variation in parasite loads and possibly spawning times and age structure have been interpreted as indicating the presence of substocks in the North Pacific, but the evidence is inconclusive.

It therefore seems reasonable to predict that Ray's bream in New Zealand undergo seasonal migrations (southward in summer), and that larger fish penetrate further into high latitudes than do smaller fish. There is currently insufficient information to determine whether there is more than one stock in the South Pacific.

Pacific Ocean catch and catch per unit effort

Nothing appears to have been reported on non-New Zealand catches of Ray's bream in the South Pacific.

Ray's bream in New Zealand

Ray's bream was first recorded from New Zealand by Hutton (1875) as *Toxotes squamosus*. Up to the late 1990s, there had been virtually no research on the species in New Zealand. Many popular fish books reported it as being present, but rare (Graham 1956; Parrott 1957; Doogue & Moreland 1961; Ayling & Cox 1982; Moreland 1983). They state that Ray's bream average about 40–50 cm fork length, reach about 60 cm, and are pelagic or mesopelagic, occurring near the surface or in midwater to depths of several hundred metres. Paulin (1981) noted that Ray's bream were locally abundant in New Zealand, and that they ranged between the Bay of Plenty and Banks Peninsula and Hokitika.

During the last few decades, information on Ray's bream has been collected by Ministry of Fisheries scientific observers aboard commercial fishing vessels, and by Ministry and NIWA scientists aboard research vessels. These data were analysed in some detail during the late 1990s, and now provide a clearer picture of the distribution and size composition of the species in New Zealand waters.

Bailey et al. (1996) reported that Ray's bream are taken by purse seiners, trollers, and longliners targeting tunas in the New Zealand EEZ. They also noted that bramids, mainly Ray's bream, constituted about one-third of the catch of a driftnet vessel in the Tasman Sea. Bailey et al. (1996) stated that Ray's bream were a common bycatch of tuna longliners working off the west coast South Island, especially during the morning and afternoon when the fish rise to the surface. Subsequent analyses of ten years of scientific observer data collected aboard tuna longliners show that Ray's bream occur throughout the New Zealand EEZ (from 30 to 50° S), but that their abundance is greatest in the southern part of their range (Francis et al. 1999; 2000; Bagley et al. 2000). Based on scaled up scientific observer data, an estimated 7–10 t of Ray's bream are caught annually by the tuna longline fishery (Francis et al. 2000; 2001). Most of the catch (83%) is alive when brought to the boat, and most (84%) is discarded (Francis et al. 2001).

Ray's bream are also taken by research and commercial bottom and midwater trawlers over the latitude range 37–53° S, and most frequently over depths of 300–700 m (Anderson et al. 1998; Hurst et al. 2000).

The amount of Ray's bream reported landed on Licensed Fish Receiver Returns averaged 491 t (range 421–693 t) per year between 1994–95 and 1999–2000 (Table 2). Since only a small fraction of this is attributable to the tuna longline fishery, most of the catch presumably comes from trawlers. Scientific observer records indicate that in trawl fisheries which catch a significant amount of Ray's bream, most of the catch is kept (Table 3), whereas in fisheries that catch small quantities it is generally discarded (Anderson et al. 2000; Clark et al. 2000).

Table 2: Landings of Ray's bream reported on Licensed Fish Receiver Returns

Fishing year	Landings (tonnes)
1989–90	284
1990–91	211
1991–92	295
1992–93	342
1993–94	160
1994–95	460
1995–96	693
1996–97	421
1997–98	520
1998–99	431
1999–00	423

Table 3: Percentage of catch of Ray's bream discarded in observed trawl fisheries. Sources: Anderson et al. (2000), Clark et al. (2000).

Target species	Period	Catch of Ray's bream (t)	Percentage kept
Jack mackerel	1990–91 to 1997–98	39	98.5
Arrow squid	1990–91 to 1997–98	144	98.4
Hoki	1994–95 to 1995–96	41	76.3

Spawning and larval distribution

Nothing is known about spawning of Ray's bream in New Zealand. In the North Atlantic, Ray's bream spawn over a protracted period between spring and autumn. Spawning may occur at different times of year in different latitudes, with a preference for temperatures greater than 19.5 °C (Mead 1972). Juveniles less than 25 mm long are found in surface waters at temperatures of 21–24 °C (Mead 1972). They appear to descend into deeper water as they grow.

In the North Pacific, Pacific pomfret spawn over a lengthy period in warm subtropical waters, and small juveniles exclusively occur there (Shimazaki 1989; Pearcey et al. 1993; Savinykh 1994).

Age, growth and mortality

Nothing is known about the growth rate, mortality rate, age at maturity, or longevity of Ray's bream in New Zealand.

The fishery for Ray's bream off north-west Africa mainly exploits two successive age groups, and progression of length-frequency modes suggests a fast growth rate of about 13 cm per year for fish 27–30 cm fork length (Rodriguez 1980). Fast initial growth is also likely for Portuguese fish, followed by a considerable reduction in growth rate; longevity is reported to be 12 years (Lobo and Erzini 2000).

Pacific pomfret grow rapidly, though there are conflicting estimates of growth rate and longevity, with the latter being variously given as 3, 6 or 9 years (Shimazaki 1989; Pearcey et al. 1993; Savinykh & Vlasova 1994; Bigelow et al. 1995). Nevertheless, it is clear that early growth is extremely rapid with fish reaching about 30 cm in their first year, and maturing during their second year.

By analogy with Ray's bream in the North Atlantic, and Pacific pomfret, it seems likely that New Zealand Ray's bream would have high growth and natural mortality rates, and low to moderate longevity.

Length-frequency distributions for Ray's bream observed aboard tuna longliners around southern New Zealand (mainly west coast South Island) consisted of a single prominent mode at 45–55 cm fork length, with most fish 40–60 cm long (Francis et al. 2000). Males and females had similar size distributions, but only about 40% of the Ray's bream were sexed. Samples from northern New Zealand (mainly around East Cape) were small and mostly unsexed, and they contained a wider range of fish sizes (30–75 cm, maximum recorded length 84 cm). The estimated mean weight of Ray's bream caught by tuna longlines in New Zealand waters in 1997–2000 was 2.0–2.1 kg (Francis et al. 2000; 2001).

Females mature at about 43 cm (unpublished observer data from trawl-caught fish), suggesting that most fish caught by tuna longlines are mature. Ray's bream caught by research bottom and midwater trawls were smaller than those taken on longlines (mainly 35–45 cm) (Hurst et al. 2000), and were probably mostly immature.

Feeding

In New Zealand, Ray's bream eat small midwater fishes and squid (Graham 1956; Parrott 1957; Doogue & Moreland 1961; Ayling & Cox 1982; Moreland 1983; Paul 2000). In the North Atlantic, they feed on a wide variety of nektonic prey, including small fishes, squid, and crustaceans (especially euphausids) (Mead 1972). In Tasmania, they feed almost exclusively on the myctophid fish *Lampanyctodes hectoris* (Blaber & Bulman 1987).

Conclusions

The information available on the basic biology, stock structure and stock size for Ray's bream is rudimentary, and most of it comes from studies in the North Atlantic. Most of the basic biological parameters required for estimating stock status are currently unknown.

Ray's bream appear to be highly migratory, and the stock fished in New Zealand waters probably ranges throughout the southwest Pacific Ocean, and possibly through the entire South Pacific Ocean. Reported landings from the New Zealand EEZ are about 500 t per year, most of which is taken by trawlers. The tuna longline fishery catches only about 10 t per year, and most of that is discarded. There is no information on Ray's bream catches from anywhere else in the South Pacific. Given the small size of the tuna longline catch, the impact of that fishery on stock is probably negligible. The impact of the New Zealand trawl fishery on the stock cannot be determined.

12. Publications

Nil.

13. Data Storage

No new data were collected during this study.

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