The Biology of the New Zealand Snapper

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Contents

[L. D. Ritchie photograph.

The New Zealand snapper.

Introduction

The abundance of snapper and its excellent qualities as a food fish make it the most important fish species in New Zealand, both to commercial and amateur fishermen. Aspects of its life history have been studied for many years and more is known about it than any other marine fish species. There are several books on New Zealand fishes in which it is included, but these do not contain much recent information and are often inaccurate or misleading.

This account presents a summary of present knowledge about the biology of snapper and is drawn from the literature shown in the bibliography on page 15 and from unpublished data of the Fisheries Research Division. At the end of each section is a list of numbers indicating literature relevant to that section. These numbers refer to entries in the bibliography.

Additional literature: 15, 16, 18, 21.

Nomenclature

The New Zealand snapper, *Chrysophrys auratus* (Forster), belongs to the sea bream family Sparidae. *Chrysophrys auratus* is our only representative of this large family, which has about 100 species and is widely distributed over the Pacific, Indian, and Atlantic Oceans and the Mediterranean Sea.

Captain James Cook correctly recognised the New Zealand species when he named Bream Bay (near Whangarei) after the large numbers of bream caught by his crew. However, the species subsequently became known as "snapper" because of its resemblance to the true snappers (family Lutjanidae), which are not found in New Zealand. The name snapper has stuck and is the only one in common use today.

Chrysophrys auratus is very similar to the Australian snappers *C. unicolor* (South Australia and Western Australia) and *C. guttulatus* (eastern states); so similar, in fact, that illustrations of the Australian species have been substituted for the New Zealand species in several books. The similarity of *C. auratus* and *C. guttulatus* has been shown recently during biochemical tests which gave identical results for both species. There is another species (the red sea bream *C. major,* from Japan) which in outward appearance cannot be distinguished from *C. auratus,* but is considered to be separate by Japanese workers because of differences in some of the skull bones. Whether all of these are really distinct species depends much on the interpretation of "species". Species do not suddenly become distinct because of geographical separation, nor do they do so at a defined time; perhaps the four species mentioned above are at present "half a species" apart.

Additional literature: 2, 20, 26, 27, 30, 33.

Description

The snapper has a deep, oval-shaped body, with a large head and powerful jaws. The fin ray counts are: dorsal, 12 spines and 10 rays; anal, 3 spines and 8 rays; and pectoral, 15 or 16 rays. The living snapper has beautiful coloration, which varies from delicate pink to dark red on its back and sides and fades to white on the belly. A series of brilliant turquoise spots is scattered along the upper part of the body. The upper margin of the dorsal fin is edged in black.

Young fish tend to be paler than adults, and in early juveniles there are five vertical bars. A large old snapper may show a blackening of the scales and occasionally have a hump on top of the head. This, the so-called "old man" snapper, may be of either sex and is much less common in New Zealand than in Australia.

Additional literature: 15, 16, 18, 21.

Distribution

The snapper is primarily a northern species (Fig. 1); its southern limits are determined by decreasing water temperatures. It is abundant along the east coast of the North Island from North Cape to East Cape, and a major fishery is centred on the Hauraki Gulf. Fewer snapper are found south of East Cape, though there is a significant population in Hawke Bay. Further south they are not common and only stragglers reach the east coast of the South Island.

Along the west coast of the North Island snapper are also abundant and large numbers are found outside harbours such as Kaipara and Manukau.

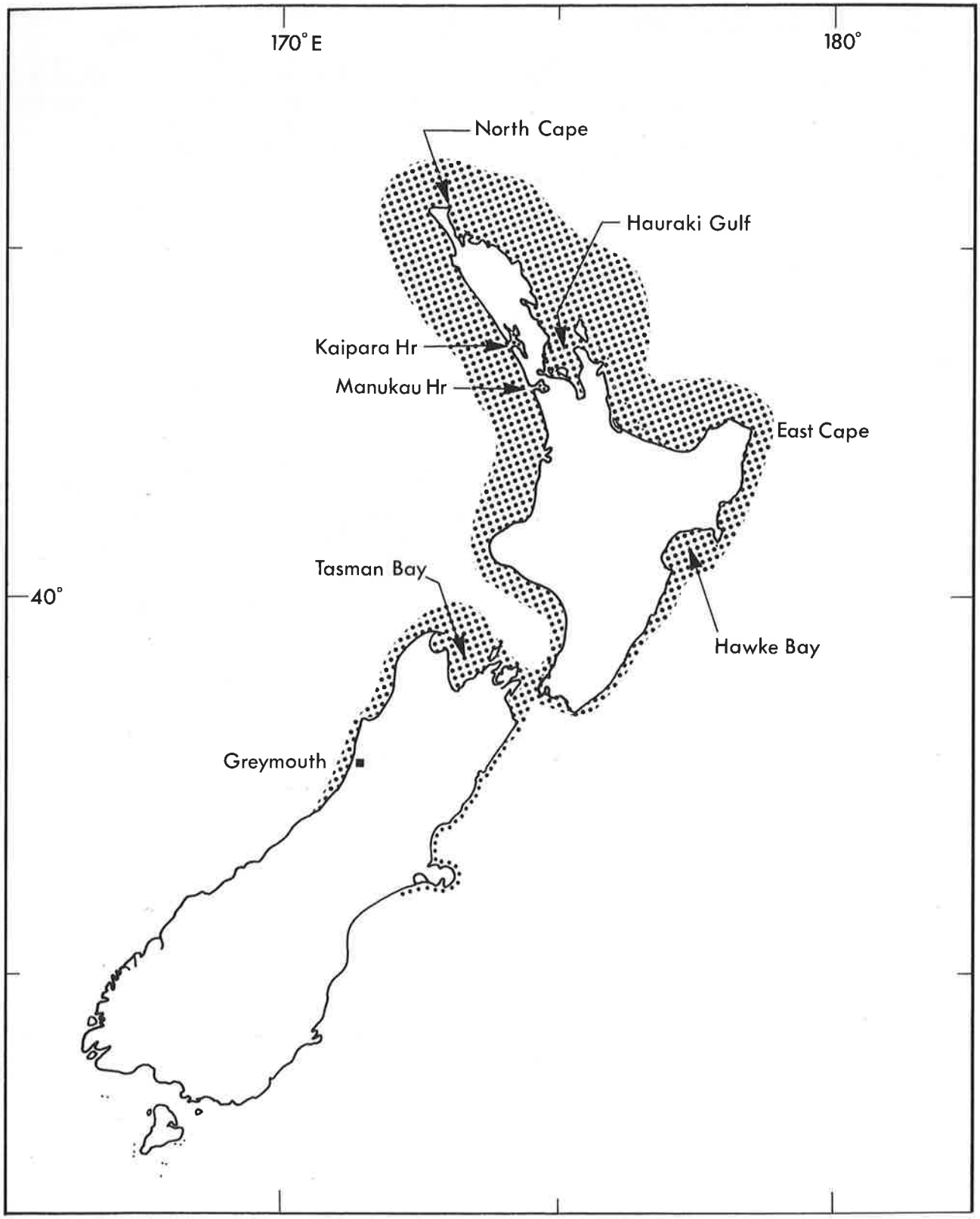

Fig. 1: Distribution of snapper. The width of the hatched area approximately indicates abundance (after Longhurst 1958).

Their distribution extends further south than on the east coast, and towards the south there is a gradual decrease in abundance.

Quite large numbers of snapper are also found in the north of the South Island. These are mainly in Tasman Bay, but there are some in the Marlborough Sounds and along the northern part of the west coast, as far south as Greymouth.

Additional literature: 1, 19, 25, 31.

Stocks

A biochemical study has shown that there are at least two genetically distinct stocks of snapper. One extends along the west coast, including the northern part of the South Island, and the other, along the east coast. The fish in Hawke Bay, though belonging geographically to the east coast stock, show more similarity to the west coast stock and may form a third stock. There is evidence for mixing of the east and west stocks at Ninety Mile Beach, and for mixing of the east stock and the possible Hawke Bay stock in the eastern Bay of Plenty and East Cape region. The genetic variation is thought to be influenced by water temperatures.

Additional literature: 19, 29.

Habitat

The snapper is a demersal fish occurring on the continental shelf down to a depth of about 200 m, but most abundant in depths of less than 70 m. It lives on all kinds of bottom—sand, mud, rocks—and is found in harbours and bays, along the open coast, and round off-shore islands. In large bays and on areas of clear bottom it is usually the dominant demersal species, particularly in the northern part of its range. In foul ground areas it is less dominant and shares its habitat with a wider range of species. Underwater observations of snapper are difficult because they are very wary and quickly move out of visual range.

Additional literature: 15, 18.

Reproduction

Sexually mature adults can be distinguished by colour differences under the chin: the males are mottled dark grey and the females are white (Fig. 2). This difference becomes more obvious with age.

Fig. 2: Sexually mature adults: male (above) and female (below).

Maturity

Investigations in the Hauraki Gulf showed that the smallest sexually mature fish were 23 cm long. Most were mature at 25 cm, and all were mature before attaining a length of 30 cm. These lengths correspond to fish that are 4 or 5 years old, which is the same age at which the Japanese species *C. major* becomes mature.

Seasonal cycle

Snapper is a serial spawner and releases many batches of eggs over a period of several months. Most of the information on snapper reproduction comes from studies made in the Hauraki Gulf, where the annual breeding cycle can be divided into four periods. The first of these, the resting period, extends for about 7 months over late summer, autumn, and winter—from February to August. The developing period preparatory to spawning occupies September. This is followed by a breeding period of about 3½ months from October to January, with peak spawning usually occurring during November. The final period, during which the spent fish recover, is very short and lasts 2–3 weeks in late January-early February.

Water temperature is the most important factor influencing the timing of the breeding period. Because snapper spawns as the temperature rises, spawning begins first in the north of its range, in the large shallow bays which are the areas that warm up most quickly in spring. The observed range of sea surface temperatures within which spawning takes place is

15°–23°C, but most occurs within the range 16°–21°C. The sea bottom temperatures are 15°–17°C at peak spawning.

Superimposed on the annual cycle is a rhythm of serial spawning during the breeding season. From a stock of developing eggs successive batches are ripened and spawned. The interval between batches is probably several days. Snapper is a daytime spawner. Spawning begins a few hours after dawn, reaches a peak about midday, and then decreases again towards dusk. As the season progresses, dawn is earlier, and spawning begins earlier. Snapper have been reported to spawn at the surface, but this is likely to be an exception. Eggs have been regularly found in samples taken close to the bottom, and it is assumed that most eggs are spawned there.

Spawning areas

Most spawning takes place in depths of 20–70 m in large bays, but snapper also spawn along the open coast. Known grounds on the east coast are Rangaunu Bay, Doubtless Bay, Bay of Islands, round Bream Head, between Little Barrier Island and Great Barrier Island, the inner Hauraki Gulf, and eastern Bay of Plenty. Along the west coast spawning is centred off the main harbours, and in the South Island it occurs in Tasman Bay.

There is no spawning where the water is very turbid or in estuarine (low salinity) areas. In the Hauraki Gulf only occasional eggs have been found in the Tamaki Strait or the inner Firth of Thames, both of which are only a short distance from dense spawning areas in the clearer waters to the north.

Eggs

These are spherical, with a diameter of 0.85–0.97 mm and a single oil droplet 0.19–0.25 mm in diameter (Fig. 3). The yolk is non-segmented. Snapper eggs are planktonic and after fertilisation float freely in the sea until hatching, which takes from 36 to 54 hours, depending on temperature.

Fecundity

The snapper's capacity to spawn many times during a season enables it to produce a very large number of eggs and is one of the reasons for its great success as a species. The number of eggs produced is proportional to the size of the fish, but it varies greatly between individuals of the same size. It may also vary between seasons, fewer eggs being produced in cold years. Egg production ranges from tens of thousands for the smallest mature fish to several million in large fish (Table 1). Not all developing eggs are spawned, and the estimates in Table 1 were made by deducting the number of resorbing eggs at the end of spawning from the potential fecundity at the start of the breeding season. The number of eggs spawned in one batch ranged from 13 000 for a 25-cm fish to 104 000 for a 50-cm fish.

TABLE 1: Fecundity of snapper from the Hauraki Gulf

Length (cm)	Fecundity 1974–75	1975–76
25	297 000	83 000
30	616 000	393 000
35	1 134 000	798 000
40	1 912 000	1 754 000
45	3 021 000	3 430 000
50	4 528 000	6 164 000

Additional literature: 4, 5, 10, 11, 12.

Larvae

The yolk-sac larvae are slightly over 2 mm long on hatching and are little developed. They live off the yolk until a functional mouth develops after 3–4 days. Young larvae can be recognised by two black pigment spots on the ventral surface of the belly (Fig. 4). Once the larvae have reached a length of about 10 mm, a full set of rayed fins has developed and the larvae are marked with five vertical bars on each side.

Little is known of the ecology of the larvae. Despite the abundance of the eggs, larvae are not common in plankton samples, and they are believed to become bottom-living very early in their development.

Additional literature: 4, 14, 28.

Age and growth

The snapper is a long-lived fish (it may live for up to 60 years) and it has a slow, variable growth rate. Aging can be done either by counting the annually produced rings on the scales (Fig. 5) or similarly by counting the rings on the otoliths (ear bones) (Fig. 6). Scale reading is reliable only for fish up to 10 years old in the Hauraki Gulf, where growth rates are slow, but it can be used up to age 20 for the faster-growing west coast snapper, where the rings are more distinct. Otoliths are more reliable for aging older fish.

Growth occurs during the warm months, mostly after the spawning season. Snapper achieve a maximum length of about 80 cm and a weight of 10 kg. In the Hauraki Gulf they reach an average length of 11 cm after their first year, 16 cm at age 2,

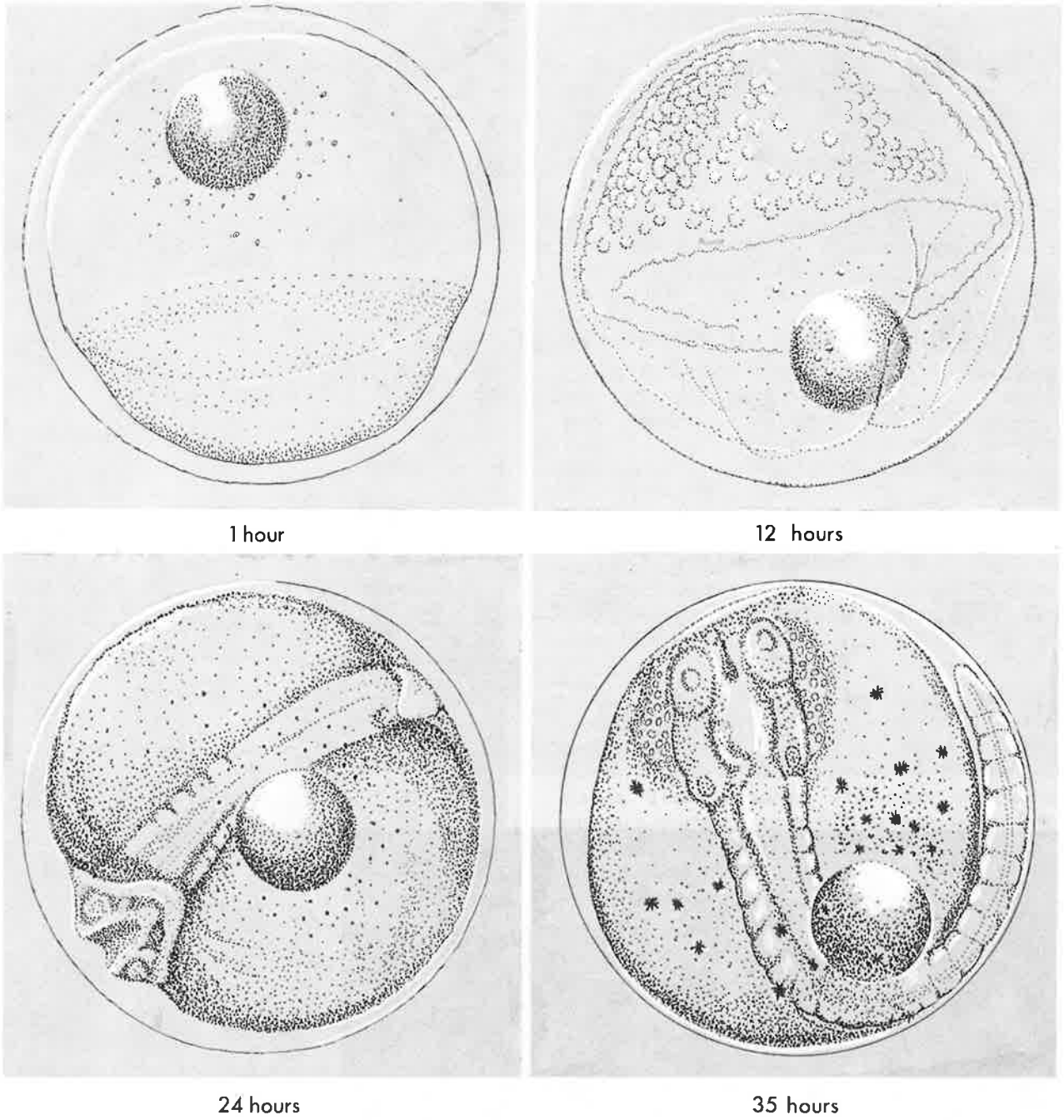

Fig. 3: Snapper egg development. Times (in hours) are for an incubation temperature of 21°C.

20 cm at age 3, and 20–24 cm at age 4. Thereafter, growth becomes progressively slower and more variable, so that, for example, a 30-cm fish could be 5–15 years old, and a 35-cm fish, 8–34 years old.

Growth rates along the other parts of the east coast are similar to those of the Hauraki Gulf, except near the southern distribution limits, where they are faster. East Cape snapper grow noticeably faster than those of the Hauraki Gulf, but at a slower rate than those on the west coast. Along the west coast where growth rates are the fastest, snapper reach a length of 30–34 cm by age 4. The boundary between the faster-growing fish in the west and the slower-growing fish in the east is the same as that found when studying genetic composition and is further evidence for the existence of distinct stocks.

Additional literature: 6, 7, 19, 23, 24, 25, 32.

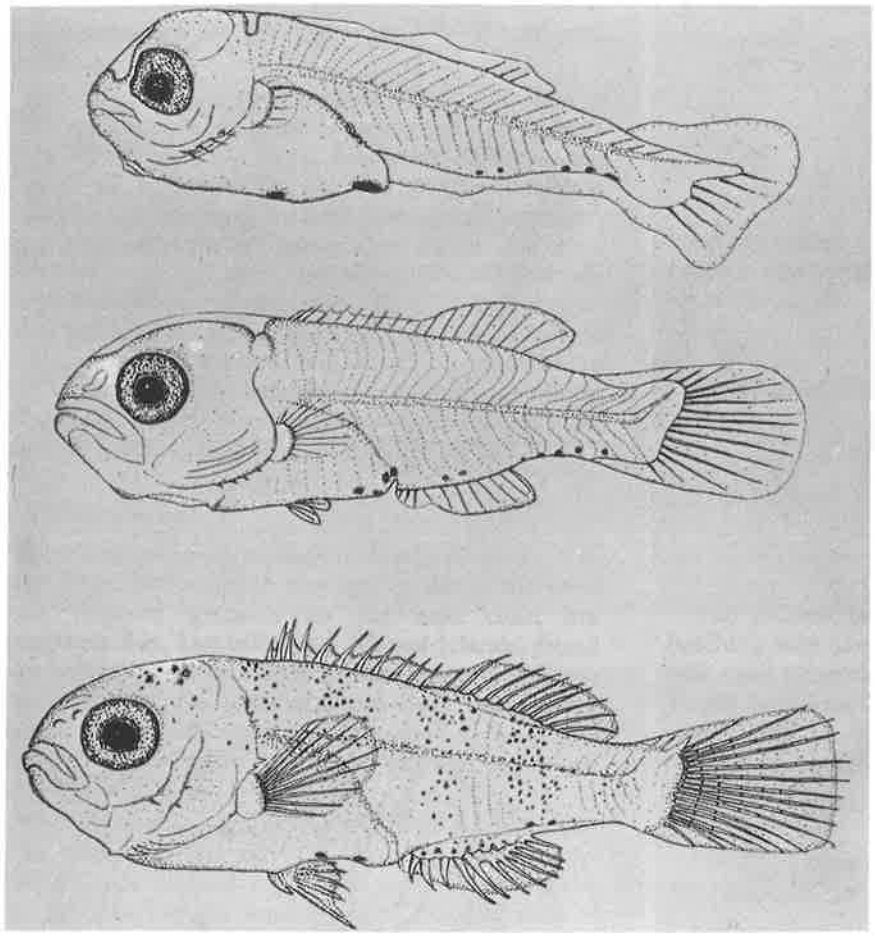

Fig. 4: Snapper larvae (5.6, 9.7, 13.5 mm).

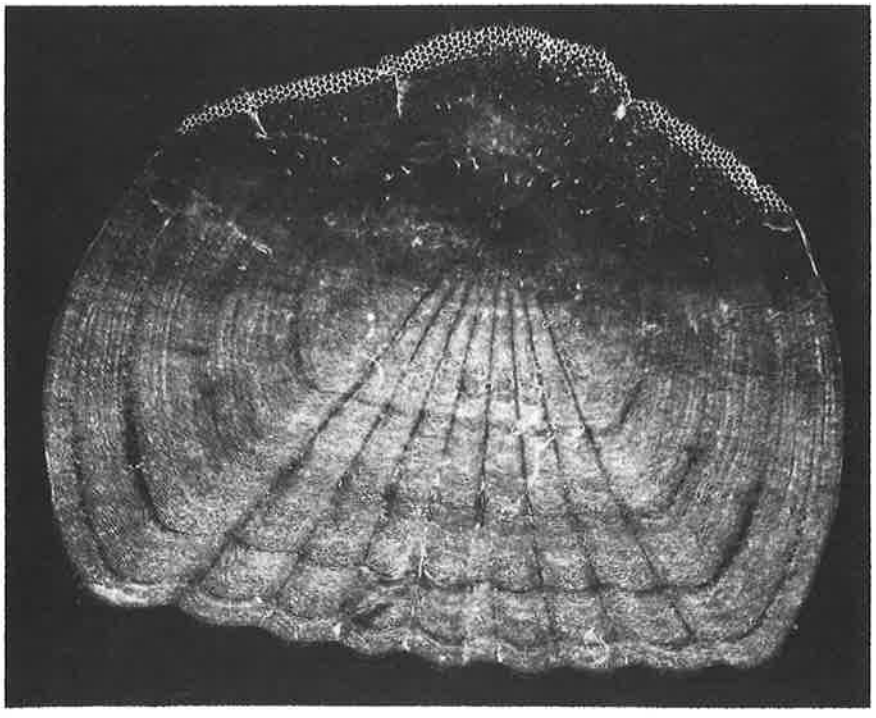

Fig. 5: Scale showing four annual rings; fish length 25 cm.

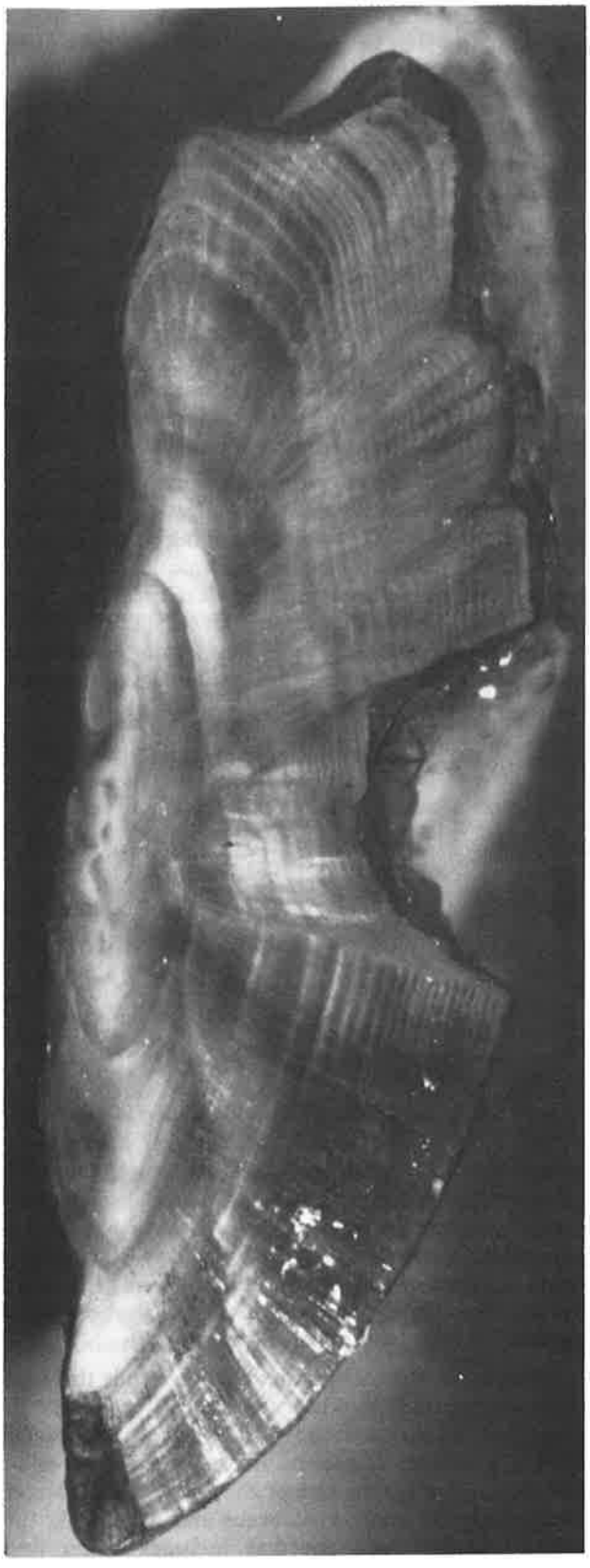

Fig. 6: Otolith showing about 20 rings; fish length 37 cm.

Mortality

Only a tiny proportion of snapper survive from the egg to become mature adults. Mortality begins at the egg stage and has various causes, the most important of which is predation by larger plankton. Other important factors are genetic malfunctions and unfavourable environmental conditions.

A female snapper living for 15 years in the Hauraki Gulf would produce about 10 million eggs. Studies in the Hauraki Gulf showed that egg mortality varies considerably: in the warm spawning season of 1974–75 egg mortality was 64%; however, in the cooler season of 1975–76 mortality was only 26%.

Separate studies have shown that in years of above average temperatures during the spawning season, more young snapper survive than in colder years. This apparent contradiction with the egg mortality figures can be explained in the following way. The effect of cool temperatures is to reduce phytoplankton* production which in turn results in a lower density of zooplankton†; thus the eggs have fewer predators. However, when the eggs hatch the situation is reversed; there is less food available for the young larvae and a bigger proportion of them die of starvation. Larval mortality rates must be high, but they have not been studied.

More is known of the mortality rates of juvenile and adult fish. Estimates of mortality (due both to natural causes and to fishing) have been made from catch curves that show the frequency of different year classes. These estimates, with other calculations, suggest a mortality rate of 46% per year for the first 6 years of life for Hauraki Gulf snapper. However, this estimate may be affected by differing year-class strength and by emigration of young fish.

Fish older than 6 years have an average mortality rate of 10% per year. The effect of variable recruitment can be seen as a fluctuation about this long-term trend. Similar rates for adult snapper have been found in east Northland and in the East Cape region. These rates are low when compared with those for similar fishes exploited in other parts of the world.

Mortality during the juvenile stage is mainly due to predation by larger fishes. Once snapper have reached a length of 25–30 cm few predators are large enough to prey on them, and fishing is the main cause of death.

Additional literature: 3, 12, 25, 32.

*Microscopic algae making up the "grass of the sea".
†Small floating animals feeding on phytoplankton and other species of zooplankton.

Population structure and size

Snapper populations contain individuals from a wide range of age groups. The first few year classes are easily the most important numerically, but older fish contribute substantially to the total weight of the stock. For example, in the Hauraki Gulf, fish 10 years and older make up 8% by numbers, but about 35% by weight. These older fish are also of major importance to the spawning potential of the population.

Populations near the limits of distribution contain proportionally more large fish than those near the centres of abundance. Trawl surveys in the eastern Bay of Plenty showed that snapper ranged in size from 20 to 40 cm; East Cape samples showed a large number of fish in the 40- to 50-cm range; and in Hawke Bay the range had a peak at 55 cm. These peripheral populations are maintained by a combination of adult fish moving in from the north and by irregular spawning success in years of above average temperatures.

Another feature of the population structure is the phenomenon of strong year classes brought about by good larval survival. These classes can be recognised many years later and occur consistently in different samples. As mentioned previously, the strength of a year class is strongly correlated with the temperature during the spawning season. Several successive years of above average temperatures can substantially boost the commercial catch 4–5 years later. Conversely, several consecutive years of below average temperatures will have an adverse effect on the commercial catch.

Juvenile and adult snapper generally occur together, but there are exceptions. Juveniles are absent from the Tamaki Strait and much of the Firth of Thames, but both juveniles and adults occur together elsewhere in the Hauraki Gulf. Although sampling over reef areas is difficult, observations by scuba divers show that both juveniles and adults are found there.

There seem to be two main factors controlling the relative distribution of juveniles and adults. Firstly, adults move around and school in specific areas at spawning time. There will thus be a time lag before juveniles can diffuse out to the furthest non-spawning areas. This diffusion, particularly in the first year of life, is probably the reason for an apparent off-shore movement by juvenile fish in winter. Secondly, there are areas where food preferences determine the relative distribution of juveniles and adults. For example, in Mercury Bay large snapper feed on shellfish close to the beach. Juveniles are unable to eat this food, and they are found further out in the centre of the bay.

The size of fish populations can be estimated by a variety of methods: for example, egg surveys, tagging, and echo counting. Each method has its intrinsic advantages and disadvantages. Egg surveys have been used to estimate the snapper population in the Hauraki Gulf, which is a particularly suitable area for study because of its fairly small size and defined boundaries. These estimates depend on knowing the total number of eggs produced by all the breeding fish during the whole of the spawning season, the average number spawned by an individual female fish, and the proportion of females in the stock. The total number of mature fish is found by combining these factors.

The results for two successive years gave similar estimates of about 78 million adult snapper with a total weight of 56 000 t. Analysis of tag return data by use of the mark-recapture technique has given somewhat lower estimates. Stock size estimates have not been made for other areas, but with these figures as a guide, the total stocks in New Zealand would be several hundred thousand tonnes. However, because the fish are slow growing, only a small proportion of them can be safely harvested each year if the population and the fishery are to survive.

Additional literature: 12, 13, 24, 25, 29, 32.

Food and feeding

Snapper is a predatory fish and its food is extremely varied (Fig. 7). Its ability to feed on almost any animal food available enables it to penetrate many different habitats and is another reason for its great success as a species. A recent example of its adaptability occurred in Tasman Bay during the warm summer of 1978, when large schools of snapper forsook their usual demersal habitat to feed on dense patches of krill in the upper water layer.

Analysis of stomach contents shows that the food eaten corresponds to whatever is locally available or abundant, and that feeding does not appear to be species selective. However, there are differences in diet depending on the size of the fish. Small snapper feed mainly on small crustaceans and worms. As the fish increase in size the diet includes larger and harder-bodied animals such as sea eggs, brittle stars, crabs, shellfish, and fishes. There is no difference in diet between males and females.

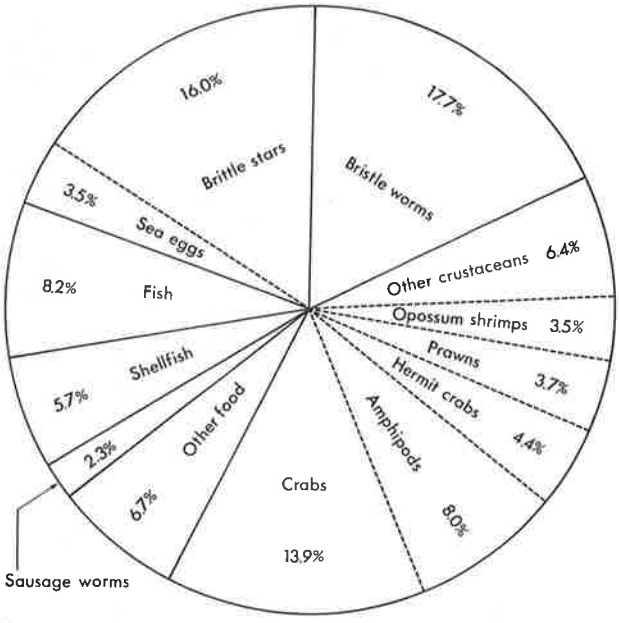

Fig. 7: Composition of the diet of adult snapper (adapted from Colman 1972).

Snapper feed mostly during the day and show different feeding patterns depending on size. Fish up to 20 cm feed during all the daylight hours, and their stomachs are fullest at about dusk. Larger snapper begin feeding at dawn and feed mostly during the morning. They also feed less frequently than small snapper.

Additional literature: 8, 17.

Movements

The changing abundance of snapper on fishing grounds has led to various theories about their movements, and the most popular of these is the "school snapper" theory. This theory supposes that fish come from an undefined area outside their spawning ground; perhaps from deeper water or from some other part of the coast.

To investigate snapper movements, extensive tagging has been done in recent years (1974–77), mainly in the Hauraki Gulf (Fig. 8). The results of this study showed that most snapper were recaptured within a few nautical miles of their tagging site. However, though they may move only a short distance, this can be quite important in relation to spawning and has a strong influence on the fishery.

In the Hauraki Gulf tag returns show that for much of the year snapper live in the in-shore areas, round the many islands of the gulf, and in the Firth of Thames. In spring and early summer they move a few miles off shore into the central gulf, where they spawn and become most vulnerable to fishing. This movement may occur repeatedly during the season as different schools go through the process of serial spawning. In the warm months of late summer and autumn, many snapper, particularly large ones, move into the shallows and harbours and penetrate right up the Firth of Thames. During winter the main body of the stock appears to remain within the gulf, along the western side and north of Waiheke Island. However, there is evidence that some fish move out to deeper water near the south and west of Great Barrier Island and return again early in spring. The results of trawl surveys in the Bay of Plenty have also shown winter movement into deeper water.

Although most movements are local, occasional long-distance ones have been observed, and these are sufficient to maintain a single stock along the east coast. Out of 707 tag returns, only 11 showed movements greater than 50 nautical miles. Seven of these were movements out of the Hauraki Gulf through the Colville Channel to an area between Great Mercury Island and Motiti Island; others were from the Hauraki Gulf to the Hen and Chicken Islands and to Marsden Point; and one was from Great Barrier Island to Cape Brett.

As well as these few long-distance movements, and the more usual local ones, there is probably a slow dispersal of juveniles away from spawning areas. Such a movement is hard to detect, but it may be the principal method by which local abundance is adjusted to the food supply.

Additional literature: 9, 22, 31.

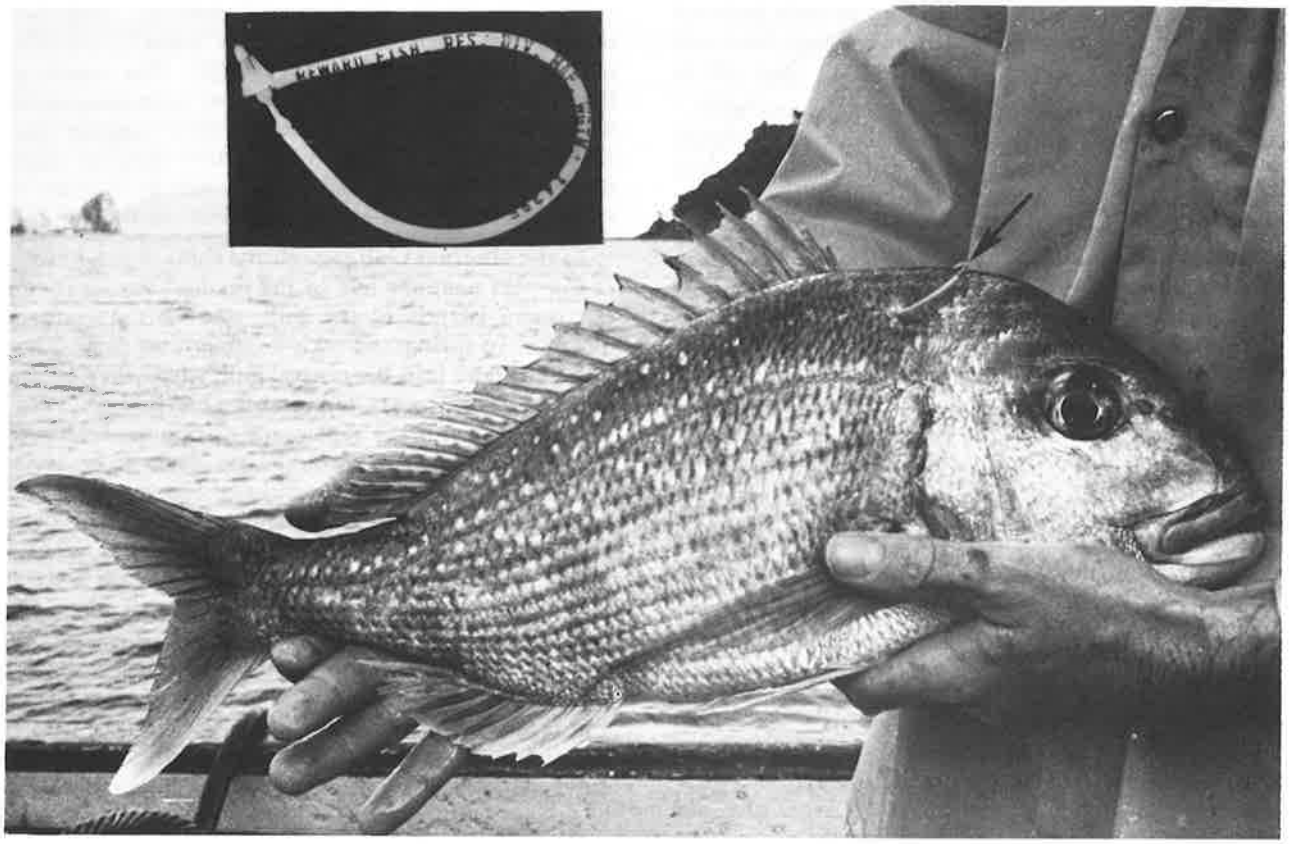

Fig. 8: Tagged snapper. Inset: a lock-on spaghetti tag.

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