more exposed shores, and the replacement of *C. columna* itself by *Elminius modestus* in brackish or sheltered conditions. The effect of the type of substrate can be seen in the absence of *Apophloea sinclairii* from Waitemata sandstone and the lower midlittoral dominance of the *Hormosira-Corallina* association on this substrate.

The combined effects of both factors can be seen in the replacement of the *Hormosira-Corallina* association on exposed coasts by red and green algal mats (e.g. Little Barrier).

The sublittoral fringe is clearly defined on the exposed coasts but this zone disappears at the more sheltered stations and here the fringe species are those dominant in the sublittoral, e.g. *Carpophyllum maschalocarpum*. I have divided the sublittoral into upper, mid, and lower sublittoral. Brown algal species such as the *Carpophyllums* characterise the upper sublittoral and a red algal belt composed of *Pterocladia-Vidalia-Melanthalia* the midsublittoral. Then follows a further brown algal zone in deeper water with *Ecklonia radiata* as the physiognomic dominant. Only if the water is sufficiently deep do all these sublittoral zones occur, and on sheltered coasts, there is frequently a telescoping of the upper and lower sublittoral with the exclusion of the red algae of the middle zone.

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Fish of the Hauraki Gulf

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This paper presents some biological and ecological information obtained from records of the last six years of catches in the inner Gulf and adjacent fishing areas by the Marine Department's fishery research trawler, *Ikatere*.

ABUNDANCE

Snapper was the most abundant commercial species caught by *Ikatere* in the inner Gulf, with gurnard second and trevally third. John dory, mackerel, kahawai, leatherjacket, various rays (especially the eagle ray) and spotted dogfish were all reasonably common. Flounder and lemon sole were caught in small numbers along the south-eastern and eastern shores. Tarakihi, second in commercial importance to snapper, was plentiful in the outer Gulf and Bay of Plenty (immediately south-east of the outer Gulf) in the deeper waters, where it accounted for practically the entire difference between snapper and the total marketable catch.

Annual percentages of snapper in relation to the total marketable species are shown in Table 1.

Numbers alone do not give a measure of productivity. A unit which includes fishing effort (i.e., numbers of legal-sized fish per fishing hour) has therefore been introduced into the table for comparison. This unit is not readily compared with commercial standards of weights and values, but it is fairly adaptable and shows clearly the relative states of the various grounds as judged by *Ikatere's* trawling records. The total marketable catch has been chosen for this comparison because this affects the availability of fish to the public rather than a unit involving one particular preferential species.

Year	Catch and Legal Fish/Fishing Hour	Inner Gulf Market Species	Inner Gulf % Snapper	Outer Gulf Market Species	Outer Gulf % Snapper	Western Bay of Plenty Market Species	Western Bay of Plenty % Snapper
1953	Total Catch	18,545	87%	4,153	83%	0	—
	Legal Size	11,625	85%	1,839	60%	0	—
	Legal Fish/Fishing Hour	136.7	—	86.9	—	—	—
1954	Total Catch	8,633	83%	1,327	71%	1,428	41%
	Legal Size	7,394	82%	1,011	62%	1,331	37%
	Legal Fish/Fishing Hour	156.2	—	112.3	—	153.5	—
1955	Total Catch	1,314	99%	0	—	506	35%
	Legal Size	1,150	99%	0	—	461	35%
	Legal Fish/Fishing Hour	313.4	—	—	—	23.3	—
1956	Total Catch	7,518	97%	3,149	78%	660	33%
	Legal Size	5,693	97%	2,277	70%	554	21%
	Legal Fish/Fishing Hour	469.7	—	82.6	—	33.9	—
1957	Total Catch	2,970	52%	10,979	60%	1,160	9%
	Legal Size	1,898	37%	6,999	45%	1,110	9%
	Legal Fish/Fishing Hour	135.6	—	93.1	—	115.9	—
1958	Total Catch	23,683	70%	5,808	82%	381	18%
	Legal Size	17,228	63%	3,975	76%	362	16%
	Legal Fish/Fishing Hour	381.7	—	78.2	—	120.7	—
1953 to 1958	Total Catch	62,663	80%	25,416	71%	4,135	28%
	Legal Size	44,988	76%	16,101	60%	3,818	24%
	Legal Fish/Fishing Hour	217.0	—	87.6	—	66.6	—

TABLE 1.—*Numerical Catch of Snapper Compared with Total Marketable Species.*

Figures for the inner Gulf were generally much higher than for the other regions. However, much of the inner Gulf is closed to commercial trawling and danish seining, the combined efforts of which account for 88% of the total landings at Auckland. The fishing effort for these confined waters contrasted markedly with the other two open areas which supply a major portion of the commercial catch.

LENGTH FREQUENCIES AND GROWTH RATE

Because of its commercial importance, snapper has received the greatest attention. Measurements have been made of the fork-length in half inch intervals. Modal lengths were usually clear in fish below 12 inches, but were unreliable age-length indicators beyond this, due to the reduced growth rate. The most comprehensive and comparable data have been selected for Table 2. The catch for December 1958 showed few modes due to the large mesh used, thus allowing an easy escape of small fish. The significance of this will be discussed under the heading of migration.

Growth rates of other species are still in doubt. Modes from a sample of 6416 gurnard, taken during the summer of 1957-58, showed at 6, 9, possibly 11, 12½ and 13½ inches. These lengths probably represent fish of one to five years. Catches of small trevally in the Gulf have been too few for growth rate determinations. Of 817 fish taken during the summer of 1957-58, the most persistent modal length was 13 inches, which probably indicated the size of the major schooling population.

REPRODUCTION

Snapper are known to spawn in the inner Gulf between mid-November and mid-January between Tiri Tiri Island, Kawau Island and the western coast. Another small ground in the south-eastern area has been reported by Thames fishermen, the spawning taking place about six to eight weeks earlier. Ap-

parently, this species requires a surface water temperature of about 19°C for spawning, and it is not yet known whether the fish shed their eggs in the water mass above the thermocline or indiscriminately throughout.

Eggs of a variety of sizes were distinguished in the surface plankton samples collected during successful snapper spawning seasons in the inner Gulf. Average sizes of the common spherical eggs were as follows:—snapper 0.91 m.m., gurnard 1.33 m.m., john dory 1.95 m.m., trevally and kahawai both 0.80-0.88 m.m., and yellow-eyed mullet 0.87 m.m. Of these, gurnard eggs were very common. The elliptical anchovy eggs were sporadically numerous. All these species are known to be capable of spawning during the snapper season. Several species of unidentified eggs were present in small numbers. All the above species except yellow-eyed mullet have a single oil globule. and are very similar in appearance except for size.

The early development of the snapper has been closely observed from artificially fertilised eggs to the stage of the absorption of the larval yolk sac. However, the young larvae have not been found in the surface plankton samples. In contrast, larvae and post-larvae of gurnard, john dory and anchovy have probably been identified in plankton samples collected for tarakihi life-history projects.

Food

Our present knowledge of the food taken by the commonest commercial species has been restricted to trawl-caught fish.

For snapper, the general diet consisted mainly of bottom fauna including various crustaceans (especially hermit crabs), shellfish (mainly bivalves), brittlestars and worms. Occasionally small squids were taken, while salps were voraciously devoured in season. The food elements were generally large enough to be recognised by the unaided eye. A sample examined from any single trawl catch generally showed a fairly large proportion of fish with empty stomachs and guts. Thus bottom-dwelling snapper were there for two purposes—feeding and resting.

However, the type of diet stated above may be confined to the more sedentary population of snapper. Immediately prior to and during the spawning season, school snapper become very prominent in the inner Gulf. These fish are of uniform size (about 12 inches), are brightly coloured and move in large groups. They have sharp teeth in contrast to the blunt, almost plate-like teeth of the "residents". School snapper appear to come from the outer Gulf, and may have been living a more active mid-water existence with a consequent change in diet.

The feeding habits of gurnard have been impossible to assess from trawl-caught specimens, because they have come on board with the stomach almost invariably everted. However, Graham states that they use their digit-like free pectoral fin-rays for feeling their food which consists of mobile bottom fauna mainly, together with free-swimming shrimps, cephalopods and small fish.

Trevally have also been examined, but not from this particular region. Their food has been similar to that of bottom-dwelling snapper, but the elements have been smaller.

Migrations

Most of the tagging in the Gulf has been concentrated on snapper. Trawl-caught fish are useless for the purpose, but over 2,000 line-caught fish have recently been tagged, mainly in shallow waters round Great Barrier Island during the summer months. Spawning fish and those in deeper waters have not yet been successfully tagged.

Returns of tagged snapper have shown some interesting facts. So far, of nineteen detailed recoveries, fifteen were taken within a mile or two of the points of release. Two tagged in the inner Gulf were found about 25 miles away, one from the outer Gulf about 40 miles, and the fourth from Great Barrier about 260 miles, being recovered off the northern headland of Poverty Bay (south of East Cape) four months after its release. The other travellers had been at liberty from eight to sixteen months. Thus, the majority of these inshore snapper appeared to be "residents", although they may have moved away and returned the following summer—a possibility which is indicated by the recovery date of some of the fish agreeing closely with the anniversary of the tagging.

Area	*Source*	*Date*	*Mesh Size of Net*	*n*	*% under 10 in.*	*% over 12 in.*	*Modal Lengths Expressed in Inches*									
							Age in Years:—									
							1	1½	2	2½	3	3½	4	4½	5	5½
Gulf	Marine Dept. Bull. 11	1955	—	—	—	—	4	5.7	7.0	8.0	9.0	9.8	10.5	11.1	11.6	12.0
Inner Gulf	Waiheke & Environs	Aug. 1956.	1½ in.	3331	35%	45.3%	—	4.0	—	7.0	—	9.5	—	11.0	—	12.0
Outer Gulf	Mercury Is.—Barriers	Aug. 1956	1½ in.	610	31.0%	40.0%	—	—	—	8.0	—	9.5	—	11.0	—	12.5
Outer Gulf	Mercury Is.—Barriers	Jan./Feb. 1957	1½ in.	6010	52.6%	25.7%	5.0	—	7.0	—	9.0	—	10.5	—	12.0	—
Inner Gulf	Longhurst L/F Tiri Tiri	March 1958	—	652	—	—	4.0	—	6.8	—	9.0	—	—	—	—	—
Inner Gulf	Longhurst Scale Data	March 1958	—	652	—	—	3.8	—	7.1	—	9.3	—	11.2	—	—	—
Inner Gulf	Waiheke-Coromandel	Dec. 1958	5 in.	7336	36.5%	33.7%	—	—	—	—	9.0	—	—	—	12.0	—

TABLE 2.—*Length-Frequencies of Snapper in Hauraki Gulf.*

Besides this factual evidence, there also appears to be a seasonal inshore-offshore movement—the larger, commercial-sized fish being found inshore in winter, while the smaller fish frequent these waters in the summer. This is borne out in the shallow water catch figures listed in Table 2. When a small mesh net was used, 31%-35% of the catch was immature (under 10 inches) during August, while it rose to about 53% during the summer. The 5-inch mesh noted in the last entry would allow most of the immature fish to escape, yet the percentage still stood at 36.5%, thus indicating a much higher proportion of small fish in the inshore population during December.

Movements of other species in the Gulf are very little known. Records of trawl catches, however, seem to show some sexual segregations and migrations in certain Elasmobrachs. During the spring and summer, eagle rays showed a proportion of three males to one female (150 specimens) in the inner Gulf compared with two females to one male (66 fish) in the outer Gulf. During the winter, both regions produced a preponderance of females (67 specimens). Sexual segregation of spotted dogfish has also appeared. In the eastern shallow waters of the inner Gulf during spring and summer, three males were caught to every two females (140 fish), while the position was exactly reversed in the winter months on the western side of the inner Gulf (51 specimens). Outer Gulf figures showed no such segregation during the summer (63 fish), but during the spring, females outnumbered males by five to one (29 fish). Other Elasmobranchs were too few for such examination, but sexual segregation was not obvious.

This contribution deals with only those fish which spend some part of their time on or near the sea-bottom. The recently acquired mid-water trawl net will open up entirely new fields of research into the biology, ecology and behaviour of our marine fishes, and the efficient handling of it is awaited with keen interest.

NOMENCLATURE OF FISH

Teleosts:

Flounder (dab)	— *Rhombosolea plebeia*
Gurnard	— *Trigla kumu*
John Dory	— *Zeus faber*
Kahawai	— *Arripis trutta*
Leather Jack (cream fish)	— *Cantherines scaber*
Lemon sole	— *Pelotretis flavilatus*
Mackerel (yellow-tail)	— *Trachurus declivis*
Snapper	— *Chrysophrys auratus*
Tarakihi	—*Cheilodactylus macropterus*
Trevally	— *Caranx lutescens*
Yellow-eyed mullet	— *Agnostomus forsteri*

Elasmobranchs:

Eagle ray	— *Aetobatus tenuicaudatus*
Spotted dogfish (pioke)	— *Mustelus antarcticus*

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