Catch rates, size composition, and spawning condition of hoki in the Puysegur area, 1992

S. L. Ballara
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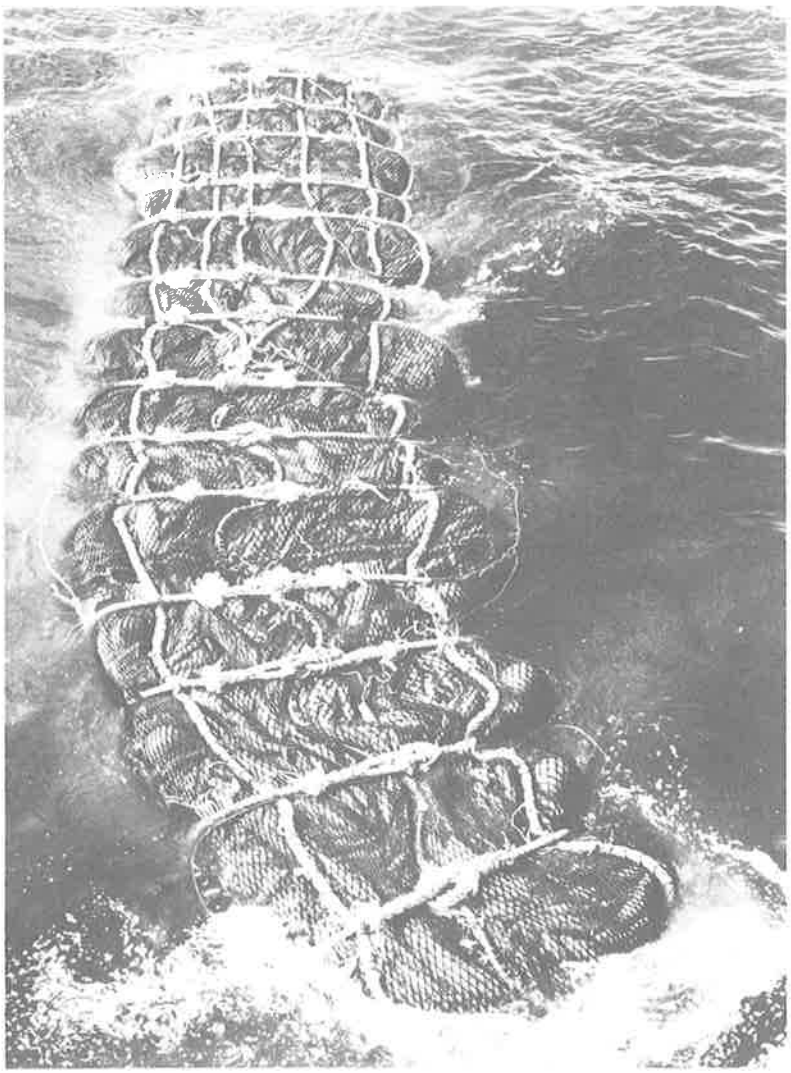

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Abstract

Ballara, S. L. & Sullivan, K. J. 1994: Catch rates, size composition, and spawning condition of hoki in the Puysegur area, 1992. *N.Z. Fisheries Technical Report No. 40.* 16 p.

In 1992, a cooperative research venture between Vela Fishing Limited and MAF Fisheries was undertaken to improve our knowledge of hoki (*Macruronus novaezelandiae*) spawning in the Puysegur area. Catch rates, size frequency distributions, spawning condition of hoki, the rate of bycatch, and catch composition were monitored. Fishing was concentrated to the southeast of the Puysegur Bank and catch rates of hoki were highest in June. Hoki made up 56% of the total catch and ling was the only other common species.

Hoki may spawn later in the Puysegur area than on the west coast of the South Island (WCSI). It appears that spawning did not occur at Puysegur in July 1992 because mainly prespawning hoki were caught. Few running ripe fish were caught in 1992, but in mid August the proportion of spent fish increased. From the 1989–91 samples there is better evidence that spawning occurs at Puysegur as running ripe fish were taken from mid August to early September.

The average size of hoki taken in the fishery increased through the spawning season, indicating that there is migration into and out of the area and that different groups of fish are being sampled during the season. The smaller fish at Puysegur may be moving north to spawn on the WCSI. Puysegur may not be a major spawning ground; possibly only hoki which do not have time to reach the WCSI spawning grounds spawn late in the season at Puysegur.

Introduction

The fishery for hoki (*Macruronus novaezelandiae*), one of the most abundant commercial fish species in the New Zealand region, is currently the most valuable in New Zealand. Hoki aggregate annually for spawning in concentrations which form the basis of fisheries on the west coast of the South Island (WCSI) and in Cook Strait. Spawning also occurs elsewhere around the South Island, including the Puysegur area.

Livingston (1990) proposed that adult hoki form two separate groups: the western stock, which lives most of the year on the Campbell Plateau and migrates to spawn on the WCSI or in the Puysegur area, and an eastern stock, which lives on the Chatham Rise and migrates to spawn in Cook Strait or in canyons on the east coast of the South Island. Numerous research trawl surveys have confirmed that most juvenile fish (about 90%) recruit to shallower waters of the Chatham Rise (Sullivan & Cordue 1994). As they approach sexual maturity (4–5 years) most of them migrate from the Chatham Rise to the Campbell Plateau; the rest remain on the Chatham Rise in deeper water. Once recruited to the adult populations the fish tend to remain in these areas, apart from migration to and from their spawning grounds.

As part of stock assessment research on hoki, scientific observers have collected size frequency and age distribution data from commercial vessels in the WCSI fishery each year since 1986. The maturity stages of female hoki have been recorded to monitor the turnover of fish on the spawning grounds, and to determine the timing and pattern of spawning. The hoki spawning season on the WCSI extends through July and August and the timing has been consistent from year to year (Sullivan & Cordue 1990). Langley (1993) suggested that the residence time for hoki may be from 20 to 27 days. The average size of hoki caught decreases as the spawning season progresses each year (Sullivan & Cordue 1992).

Length data collected by scientific observers on hoki trawlers in late August 1990 suggested that the sizes of hoki taken in the Puysegur area and on the WCSI were very similar (Sullivan 1991). However, as the Puysegur area has not been fished

continuously in any previous season, it has not been possible to monitor the spawning status or size of hoki through the spawning season.

In 1992, a cooperative research venture between Vela Fishing Limited and MAF Fisheries was undertaken to improve our knowledge of hoki spawning in the Puysegur area. Vela Fishing Limited provided vessels from a fleet of six chartered trawlers and MAF Fisheries provided the scientific personnel to collect and analyse biological samples and other relevant data on the commercial fishing operations. This report summarises the fishery in the Puysegur area since 1984 and the results of biological sampling during the 1992 spawning season. These data are compared with results from the area from 1989 to 1991 and with results from the WCSI in 1992.

The Puysegur fishery

The fishery in the Puysegur area is a small component of the New Zealand hoki fishery (Table 1). Although the bulk of the catch since 1986 has been taken in the WCSI spawning fishery, in 1992 increased catches were taken throughout the year from the Chatham Rise and the Sub-Antarctic area. Since 1989, the Cook Strait spawning fishery has become important for domestic vessels which have taken up to 27 000 t a year.

The Puysegur fishery is also based on spawning hoki: there are records of hoki catches during the winter months since 1979. Hoki are targeted mainly from June to September. The seasonal pattern of catches (Table 2) has fluctuated since 1983: for example, in August 1990 the catch was nearly 7000 t, whereas no catch was recorded in July in 1987 or 1988. The small catches of hoki outside the spawning season are mainly bycatch in the ling trawl fishery.

Table 1: Total estimated catch (t) of hoki by area

Fishing year	Puysegur	West coast South Island	N.Z. total
1983–84	5 800	20 900	50 000
1984–85	3 500	22 000	50 000
1985–86	1 900	69 800	99 000
1986–87	1 300	122 000	175 000
1987–88	1 300	220 000	255 000
1988–89	3 200	188 000	210 000
1989–90	7 300	165 000	210 000
1990–91	4 800	154 000	215 000
1991–92	4 700	105 000	215 000

Objectives

The objectives of this research were:

1. to monitor the catch rates, size frequency distribution, and spawning condition of hoki in the Puysegur area from late June to the end of August 1992;
2. to determine the rate of bycatch and species composition of trawls in the Puysegur area.

Table 2: Seasonal distribution of hoki catch in the Puysegur area (t)

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1983–84	378	95	69	5	5	0	0	37	1 657	2 271	1 053	189	5 760
1984–85	42	5	18	3	2	0	0	35	316	1 066	1 745	240	3 472
1985–86	87	37	35	8	1	< 1	2	20	938	435	218	132	1 915
1986–87	164	15	13	< 1	4	11	298	19	297	0	101	247	1 271
1987–88	324	186	12	3	0	< 1	18	3	473	0	220	62	1 301
1988–89	24	6	< 1	0	0	0	2	20	447	58	1 287	1 342	3 187
1989–90	12	116	1	2	8	2	18	3	26	5	6 956	122	7 273
1990–91	9	12	< 1	0	0	0	2	3	829	1 182	1 800	923	4 763
1991–92	2	< 1	2	4	0	7	6	80	1 277	2 229	831	238	4 675

Methods

Locality

For this study the Puysegur area is defined as the area from 46° S to 47° 30' S between 165° W and 166° 40' W (Figure 1) and includes all of the Puysegur Bank, a large shallow area southwest of the South Island. The hoki fishery is concentrated mainly on the eastern side of the bank in depths of 400–800 m.

Timetable

There was always at least one vessel fishing in the area from 26 June to 3 August 1992. There was no sampling between 4 and 18 August, and only a few samples were collected from 19 to 21 August. The vessels each spent 10–18 days fishing in the area with MAF Fisheries scientific observers on board (Table 3): 90 tows were sampled. Vessels were unable to fish continuously in the area throughout August because of quota constraints.

Vessels and gear

The vessels involved in this project (*see* Table 3) were all Norwegian owned and registered as New Zealand vessels under charter to Vela Fishing Limited. They operated from Lyttelton and Bluff and trans-shipped observers at sea, in Bluff, or in Lyttelton, as appropriate. All are modern factory trawlers with sophisticated electronic equipment, including GPS, and net monitors for both bottom and midwater trawls, capable of fishing to below 1000 m. Fishing was generally carried out on the bottom.

Table 3: Vessel dimensions, dates, and number of tows sampled

Vessel	Length (m)	Gross tonnage	Dates	No. of tows sampled
Longva 3	57.0	1 597	26 Jun–05 Jul	15
			19 Aug–21 Aug	5
Klara Birting	69.2	2 882	05 Jul–15 Jul	20
Nororn Ladd	60.5	2 280	15 Jul–01 Aug	15
Tampen	62.0	1 806	18 Jul–03 Aug	35

Sampling method

The programme was designed to sample catches taken during normal commercial fishing operations, not to randomly survey the Puysegur area. Small hoki are found year round in much of the area, but our main interest was in spawning-sized hoki (over 60 cm total length).

The scientific observers on the vessels established a sampling point in the factory where hoki had not been sorted by size (D. Banks, MAF Fisheries, pers. comm.). Samples of 100–150 hoki were collected at random times of the day, one random sample being taken within each 12 h period. Hoki were measured to the nearest centimetre below total length and their sex was determined. Ovaries were staged on a five-point scale :

Stage 1: Immature or resting

Stage 2: Ripening or maturing

Stage 3: Ripe

Stage 4: Running ripe

Stage 5: Spent

The date, number, time and position, bottom depth, groundrope depth, headline height, gear type, and catch weights of hoki and bycatch were recorded in the logbook for every tow during the trip.

Data analysis

For the length-based analysis, samples were treated individually and also pooled into 10-day periods (strata). Samples were scaled up to the weight of the tow and then combined within each stratum. These pooled samples were scaled up by the total weight of the catch in each stratum and combined.

Within individual samples, the mean length was estimated separately for male and female hoki to determine any trends over the season. The mean lengths of hoki classified by ovarian stages were analysed similarly. Changes in the proportion of each ovarian stage in the samples were studied to identify the presence and timing of spawning.

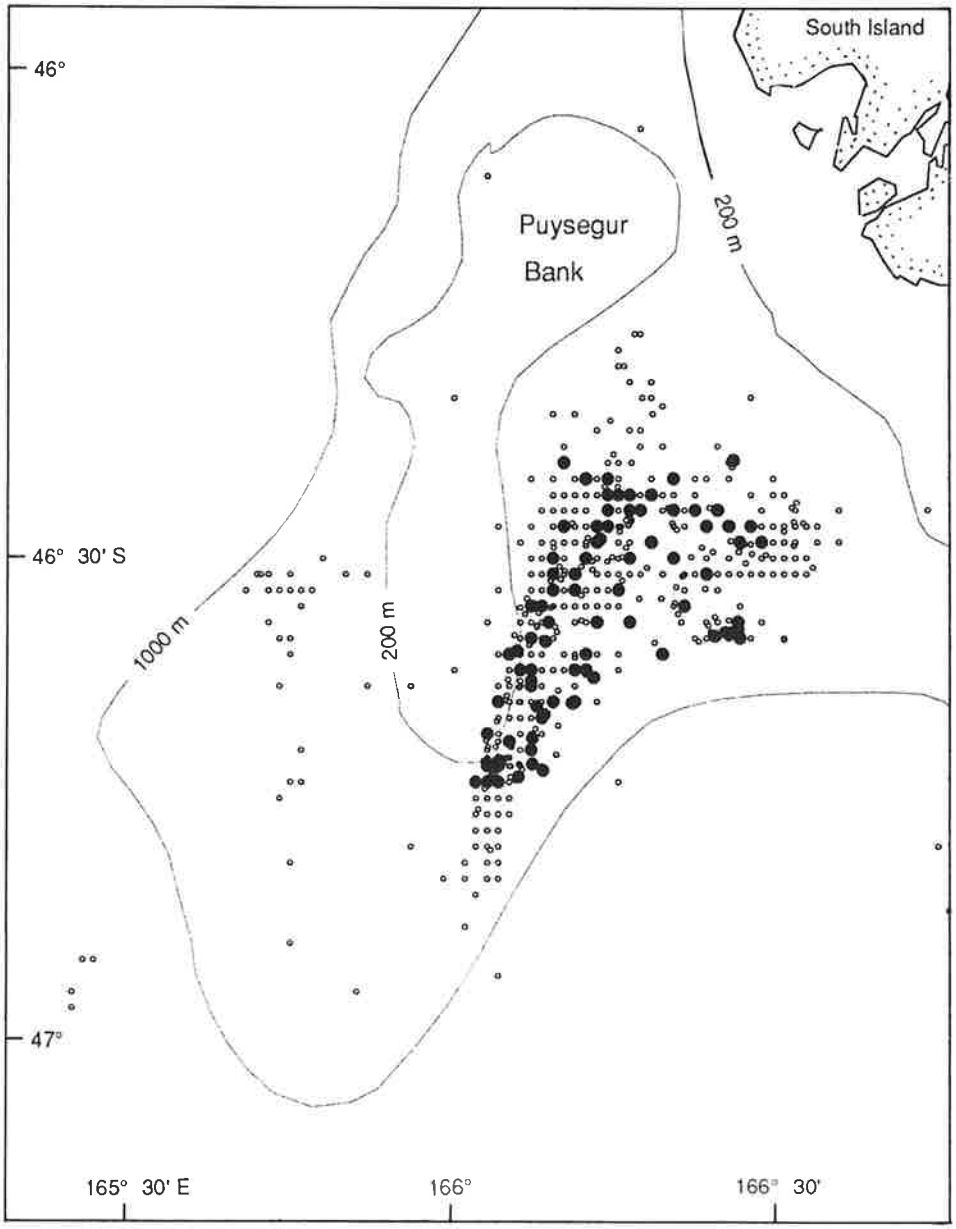

Figure 1: Survey area including Puysegur Bank, southwest of the South Island. Larger dots show the position of tows when scientific observers were on board and smaller dots the position of all other commercial catches of hoki in June, July, and August 1992.

Results

The commercial fishery in 1992

Most of the commercial catches of hoki in the Puysegur area between June and August 1992 were made to the southeast of Puysegur Bank (*see* Figure 1). Hoki (4343 t) made up 56% of the total catch: ling (1710 t) was the only other common species. Bycatch rates (the catch weight of a species expressed as a percentage of the hoki catch) were 39% for ling, 11% for arrow squid, and less than 6% for any other species (Table 4).

The catch rates of hoki in June, July, and August 1992 for all vessels in the Puysegur area are shown in Figures 2–4. Catch rates in all three months were similar. Most fishing was carried out in July and the least in August. In each month the catch rates were highest to the southeast of the Puysegur Bank. Catch rates of ling were also highest in this area (Figure 5).

Standardised catch rates in the Puysegur area were calculated for a subset of vessels which had also fished on the Snares shelf; mean catch rates were highest in June (Table 5). In August these vessels had similar, but slightly lower, catch rates of hoki on the Snares shelf where they preferred to fish when not participating in the cooperative research study.

Table 4: Total catch and percentage of hoki (bycatch rate) of species caught during fishing in the Puysegur area where hoki were reported

Species	Scientific name	Catch (t)	% of hoki
Hoki	*Macruronus novaezelandiae*	4 343	
Ling	*Genypterus blacodes*	1 710	39.38
Arrow squid	*Nototodarus* sp.	50	11.57
White warehou	*Seriolella caerulea*	254	5.85
Jack mackerel	*Trachurus* sp.	250	5.75
Red cod	*Pseudophycis bachus*	201	4.63
Hake	*Merluccius australis*	168	3.86
Silver warehou	*Seriolella punctata*	106	2.43
Common warehou	*S. brama*	36	0.82
Barracouta	*Thyrsites atun*	27	0.62
Giant stargazer	*Kathetostoma giganteum*	25	0.58
Frostfish	*Lepidopus caudatus*	15	0.35
Ribaldo	*Mora moro*	14	0.31
Gemfish	*Rexea solandri*	12	0.28
Bluenose	*Hyperoglyphe antarctica*	8	0.18
Spiny dogfish	*Squalus acanthias*	5	0.11
Groper	*Polyprion* spp.	5	0.11
Ghost shark	*Hydrolagus novaezelandiae*	3	0.07
Smooth skate	*Raja innominata*	2	0.05
Sea perch	*Helicolenus* sp.	1	0.03
Lookdown dory	*Cyttus traversi*	1	0.03
Rattails	family Macrouridae	1	0.03
School shark	*Galeorhinus galeus*	1	0.02
Others		2	0.04

Observed vessels

Depth range and area sampled

Between late June and early July, and again in mid August, the depth range of trawl shots was 600–800 m. From mid July to early August tows were mostly in shallower water from 400 to 600 m (Figure 6) along a narrow area running up the eastern side of the Puysegur Bank. Observers were on board when 781 t of hoki were taken.

Size structure

In 1992 the average size of hoki of both sexes increased through the season (Figure 7a), though occasional catches of smaller fish were taken. A similar pattern was seen in 1991 (Figure 7b). Length frequencies by stratum and sex for the 1992 season are shown in Figure 8a. In both sexes the mode of the distribution shifted to the right as the season progressed: this may reflect the arrival of larger fish in the Puysegur area. The mean length for females increased from 77 cm in late June-early July to 83 cm by early August, and for males from 72 to 77 cm.

The Puysegur area length distributions in stratum 1 (late June-early July) show the presence of a strong mode which is believed to represent fish of the 1987 year class. Both males and females are dominated by this mode with means of 72 and 77 cm, respectively. In stratum 4, the adult female length frequencies look bimodal (with a small mode at about 75 cm and a more dominant mode at about 88 cm), which is similar to the WCSI length frequencies in early August (Figure 8b). The male distribution in stratum 4 is dominated by an adult mode at about 80 cm which is much larger than the dominant mode at 71 cm on the WCSI.

Gonad staging

Within each sample, the numbers at each stage were plotted as a percentage of the total number of females. Figure 9 shows the change through the

Table 5: Hoki catch rates for a subset of commercial vessels

		Catch rate (t per n. mile)		
Area	Period	Min.	Mean	Max.
Puysegur	Jun 1992	0.007	0.814	7.467
Puysegur	Jul 1992	0.009	0.572	7.555
Puysegur	Aug 1992	0.055	0.686	4.687
Snares shelf	Jun-Aug 1992	0.007	0.595	7.555

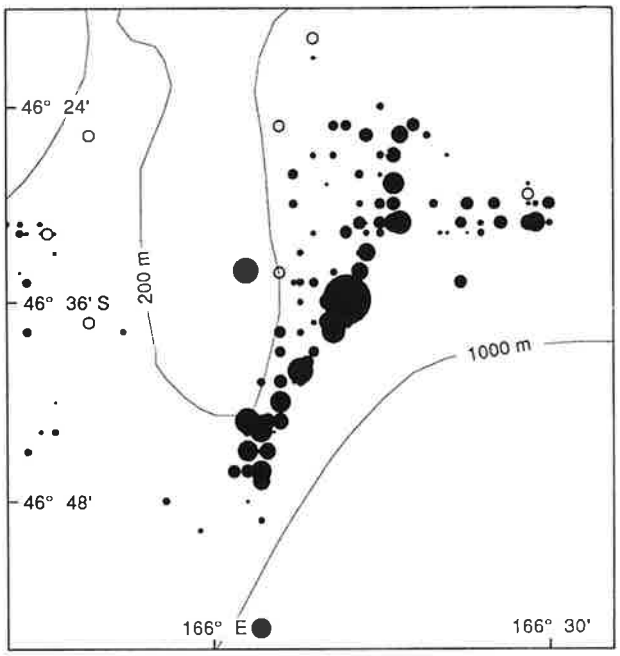

Figure 2: Hoki catch rates (t per n. mile) of all commercial trawls in the Puysegur area in June 1992. Circles are proportional to catch rate, the largest being 31 t. Open circles represent zero catch rates.

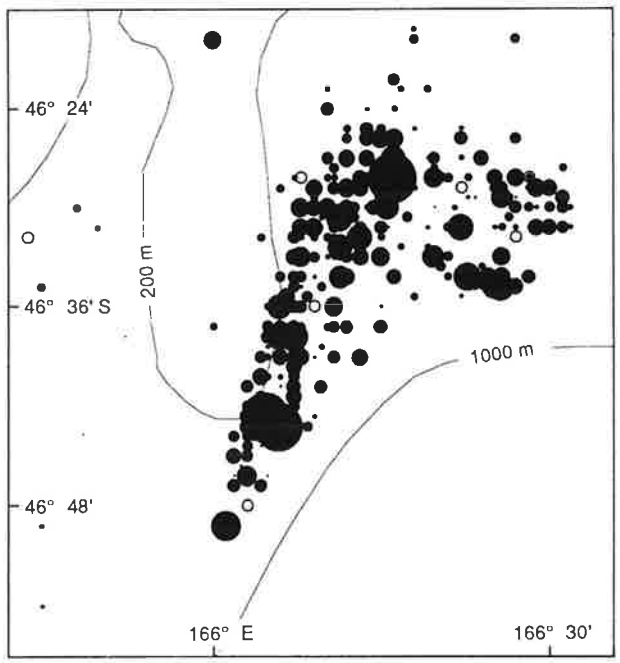

Figure 3: Hoki catch rates (t per n. mile) of all commercial trawls in the Puysegur area in July 1992. Circles are proportional to catch rate, the largest being 31 t. Open circles represent zero catch rates.

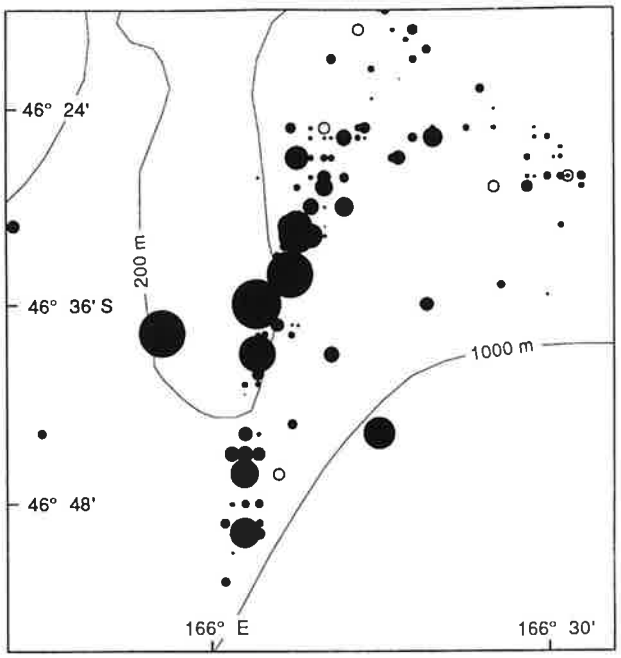

Figure 4: Hoki catch rates (t per n. mile) of all commercial trawls in the Puysegur area in August 1992. Circles are proportional to catch rate, the largest being 31 t. Open circles represent zero catch rates.

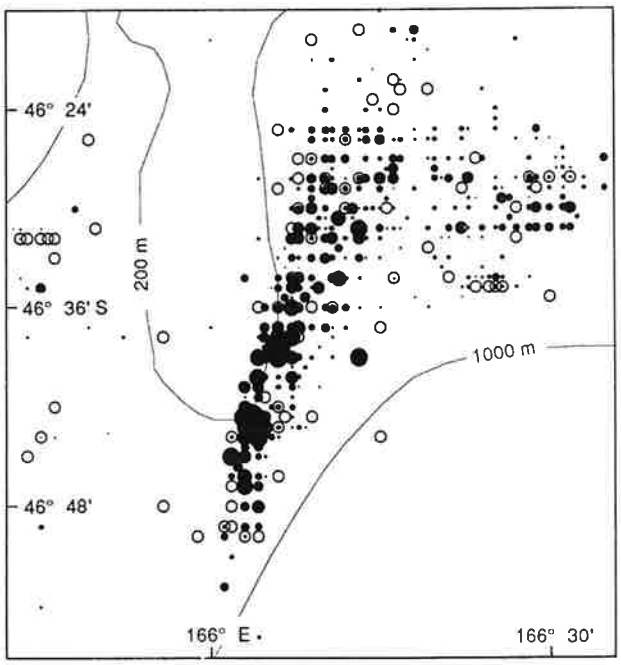

Figure 5: Ling catch rates (t per n. mile) of all commercial trawls in the Puysegur area, June-August 1992. Circles are proportional to catch rate, the largest being 31 t. Open circles represent zero catch rates.

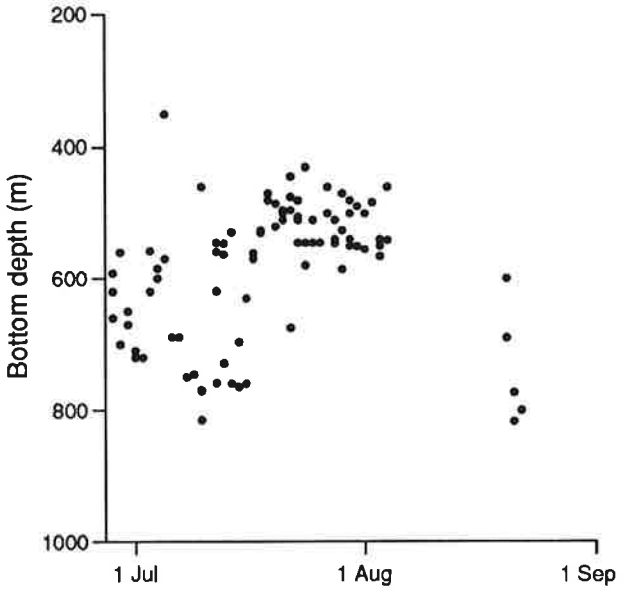

Figure 6: Depth (m) of trawl shots sampled during the 1992 fishing season.

Table 6: Percentage of hoki sampled at each ovarian stage

	Stage					No. of	No. of
	1	2	3	4	5	fish	tows
1989	15.2	9.2	20.0	40.4	15.2	936	12
1990	10.9	45.1	19.7	16.5	7.8	1 878	16
1991	7.3	64.6	13.6	2.1	12.4	3 898	36
1992	6.9	90.4	2.0	0.1	0.6	6 200	90

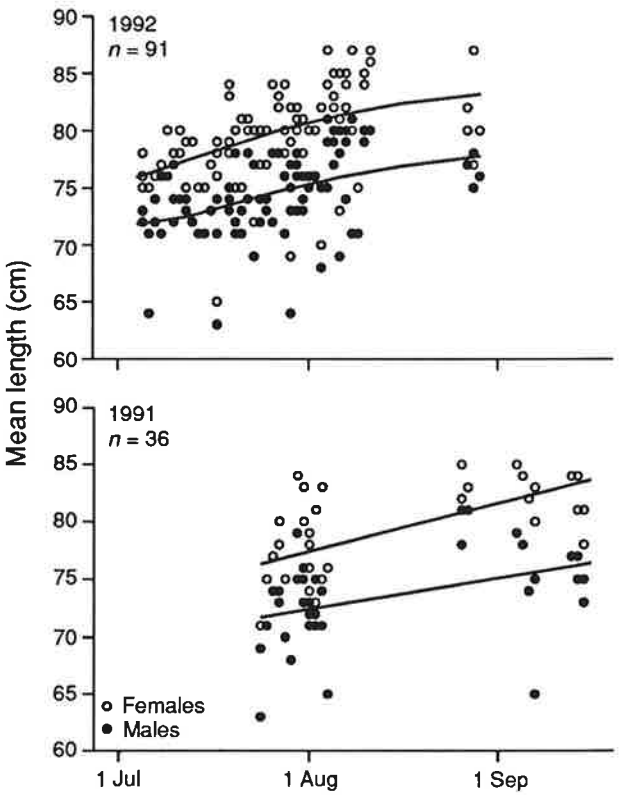

Figure 7: Daily mean length of hoki through the fishing season in the Puysegur area. Linear and quadratic relationships have been fitted to the data.

season in the proportion of stages 2–5 in 1991 and 1992. In both years there was little evidence of either running ripe or spent fish until mid August when the proportion of fish at stage 5 increased. However, the number of stage 4 fish from late August to early September 1991 is strong evidence of spawning occurring in the Puysegur area. In 1992, running ripe and spent fish appeared in the Hokitika Canyon area of the WCSI from mid July (Figure 9c).

Results from the Puysegur area in 1989 and 1990 also suggest that spawning generally occurs from mid August to early September. Although this sampling was limited, the proportion of running ripe (stage 4) and spent fish (stage 5) was much higher than in 1991 and 1992 (Table 6). Samples were taken from late August to early September in 1989 and in mid August in 1990. In 1991 and 1992, most were taken in July and spent fish were not seen before mid August (*see* Figure 9).

In 1992, 90% of the hoki sampled in the Puysegur area were at stage 2. Stages 3 to 5 were generally the largest fish, but were not well represented in the samples. The mean length of fish of stages 1 and 2 increased slightly over the spawning season (Figure 10).

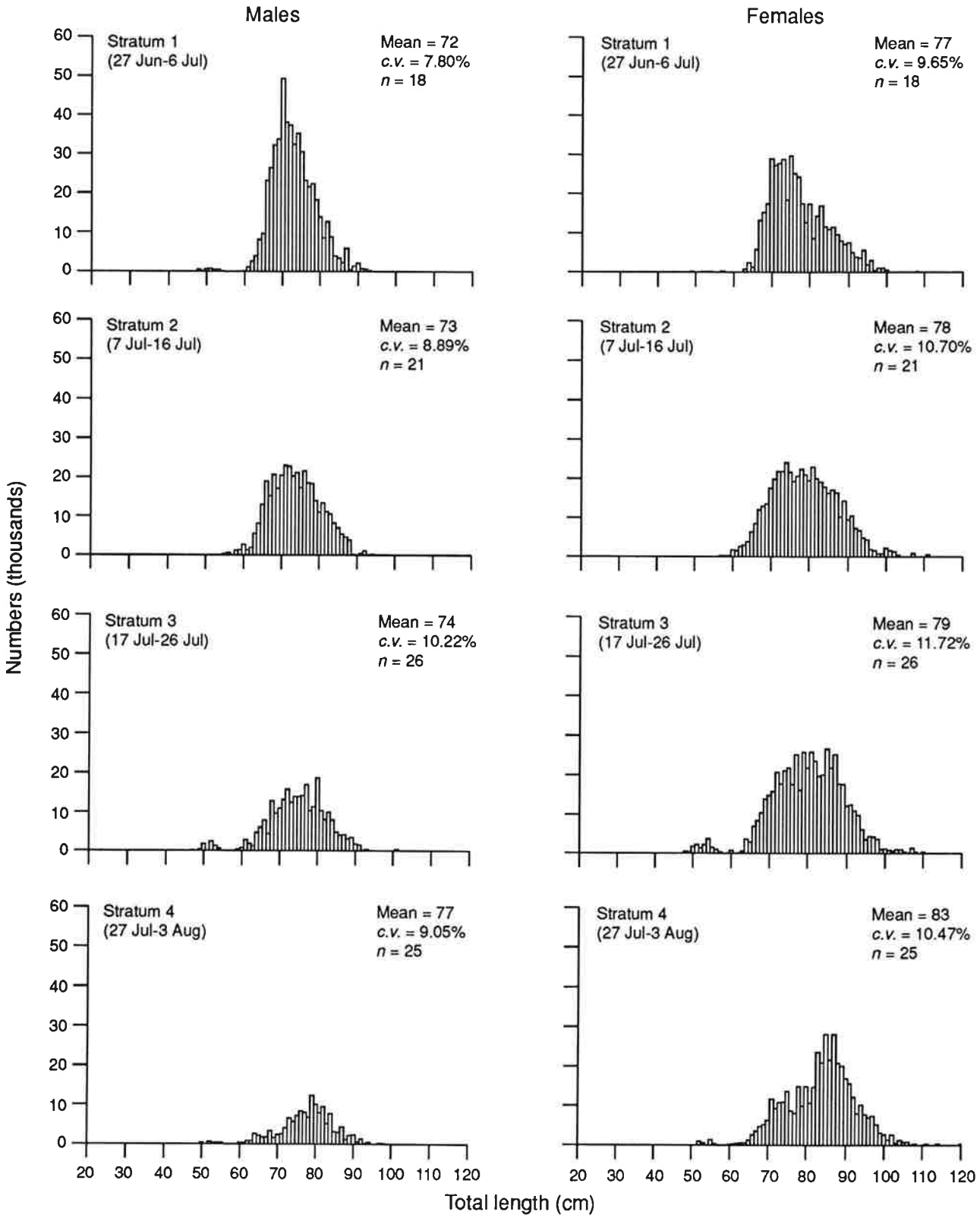

Figure 8: (a) Length frequency distributions of hoki in the Puysegur area, late June to early August 1992: 90 samples were taken by scientific observers. *n* = number of samples; *c.v.* = coefficient of variation.

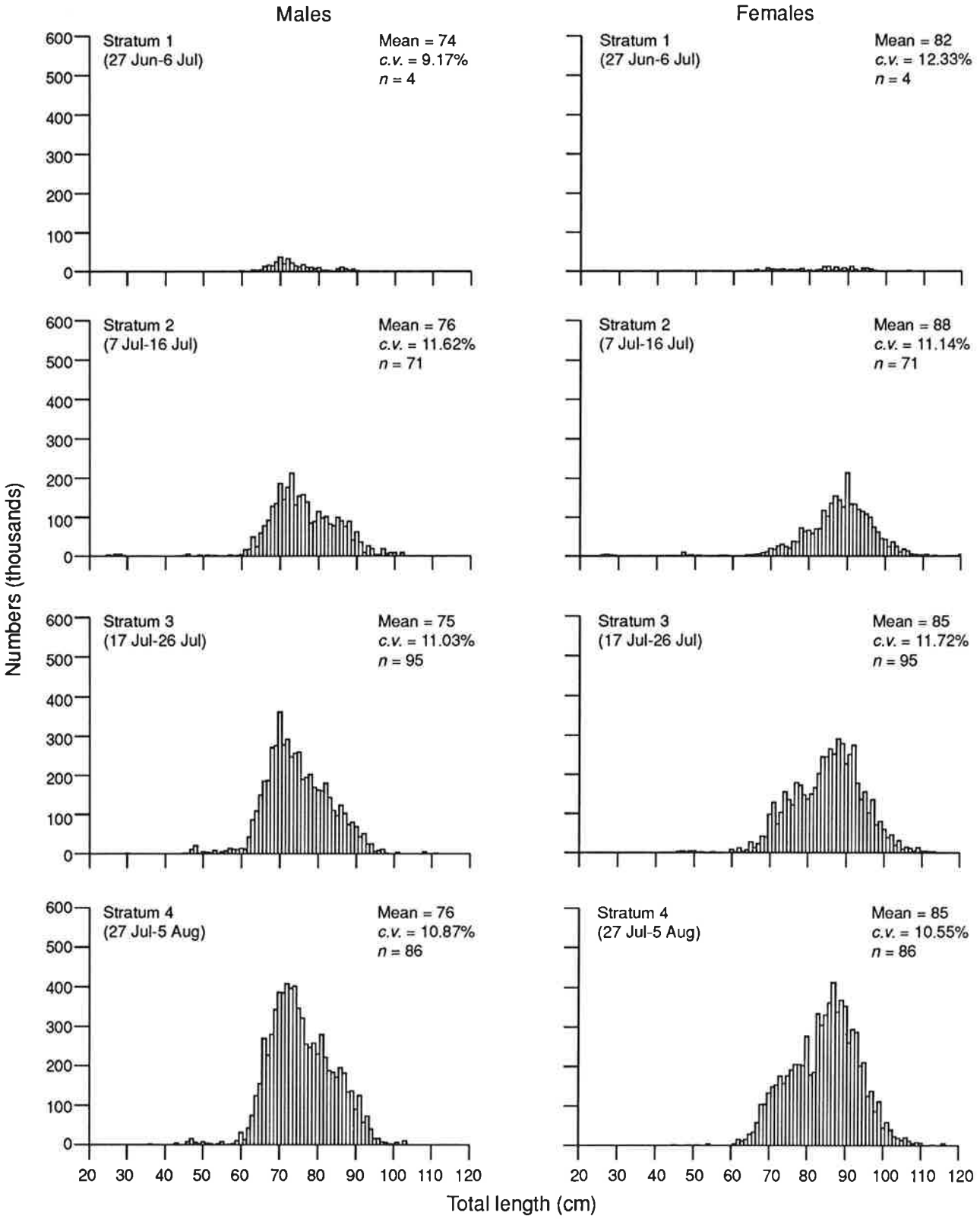

Figure 8: (b) Length frequency distributions of hoki taken in the west coast South Island fishery, late June to early August: 256 samples were taken by scientific observers. *n* = number of samples; *c.v.* = coefficient of variation.

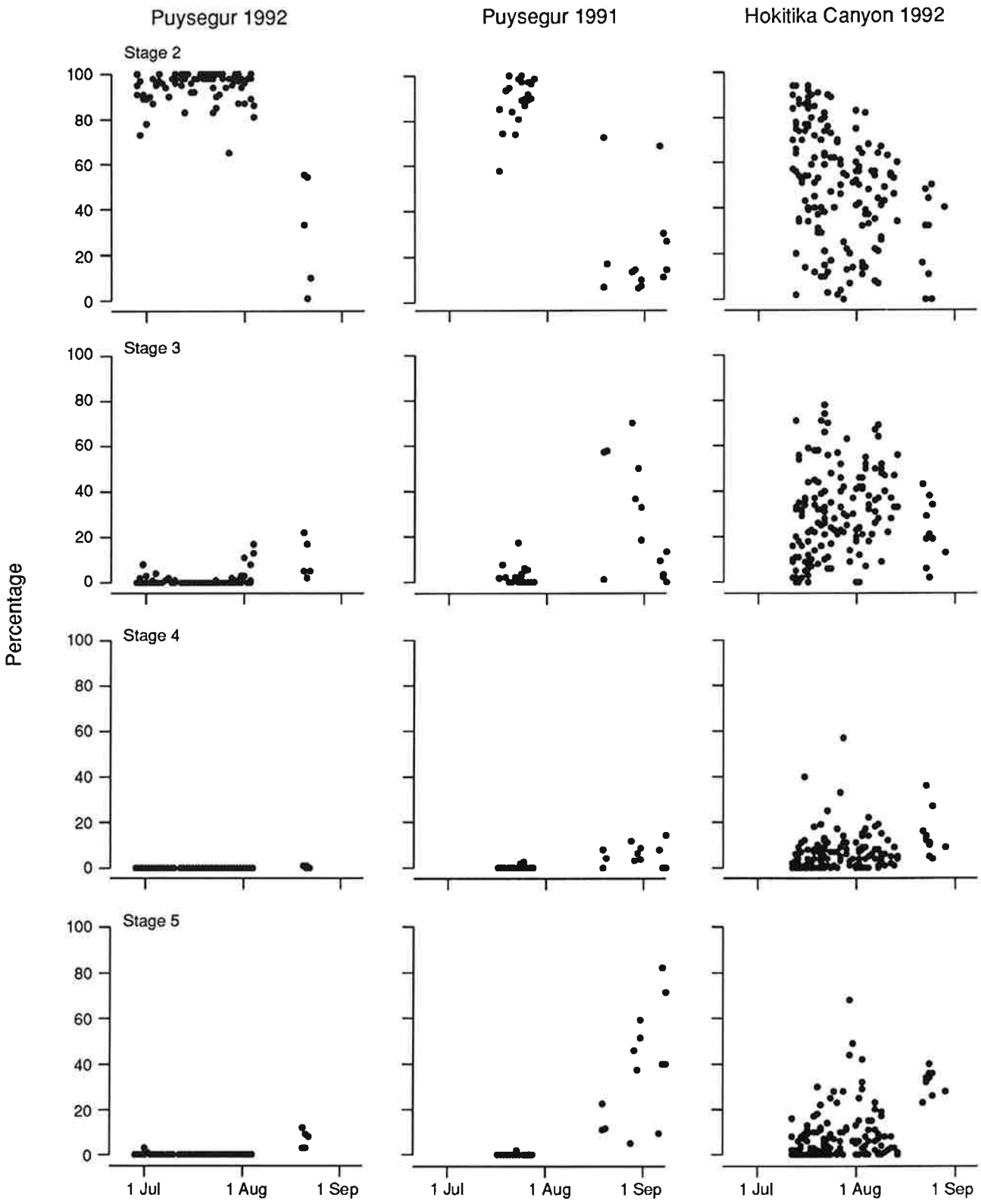

Figure 9: Percentage of female hoki at each ovarian stage in the Puysegur area, 1992 and 1991, and Hokitika Canyon, 1992.

Discussion

The hoki fishery in the Puysegur area is a small component of the New Zealand hoki fishery. The bulk of the hoki catch has been taken from the WCSI since 1986, but recently other areas have increased in importance. The pattern of fishing in the Puysegur area has changed over the last few years. In August 1990 nearly 7000 t of hoki were caught, mainly by surimi vessels targeting spawning fish with midwater trawls. Bottom trawling was the main method used in 1991 and 1992, and over the spawning season 1000–2000 t were caught each month.

Ling was a major bycatch species, particularly on the eastern side of Puysegur Bank. The distribution of the highest catch rates for ling corresponds closely with that for hoki. On the southeast side of the Bank, the catch rates of ling and hoki were the same and fishing is effectively targeted at both species.

On the WCSI the average size of hoki generally decreases through the season (Sullivan & Cordue 1992). In 1992, size increased over the season in the Puysegur area. Although the number of samples was low, especially after early August, this is consistent with data from 1990 and 1991. That this trend was not artificially created by catches of very small fish early in the season can be seen from the length frequencies in Figure 8a.

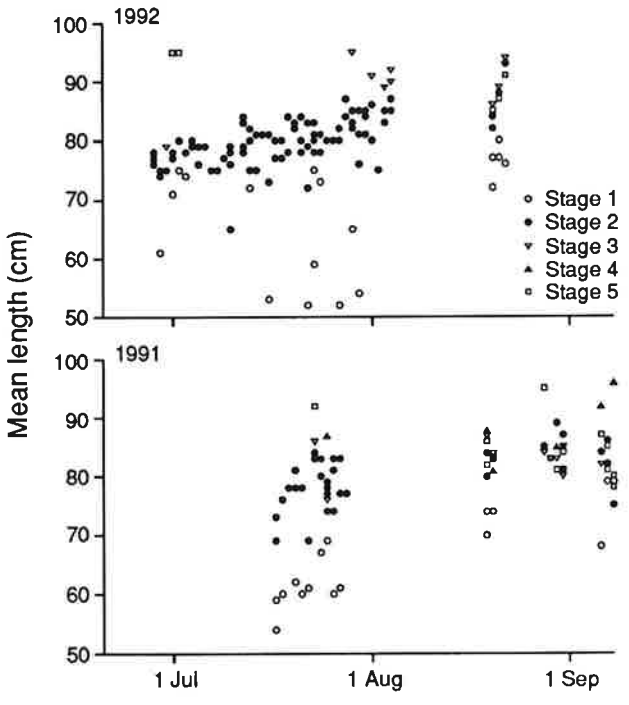

Figure 10: Mean length of female hoki at each ovarian stage by tow, Puysegur area 1992 and 1991. Number of fish at each stage ≥ 5.

Sullivan (1991) suggested that the size of hoki taken in the Puysegur area in late August in 1990 was similar to that of WCSI hoki at the same time. The length frequencies for stratum 4 in 1992 from WCSI and Puysegur (*see* Figure 8) show this. However, a major difference is that the average size of WCSI hoki decreased during the season while the average size at Puysegur increased.

Figure 11 shows that the length distribution of hoki from the Puysegur area in 1992 was similar to that in 1991, but slightly more spread. However, the

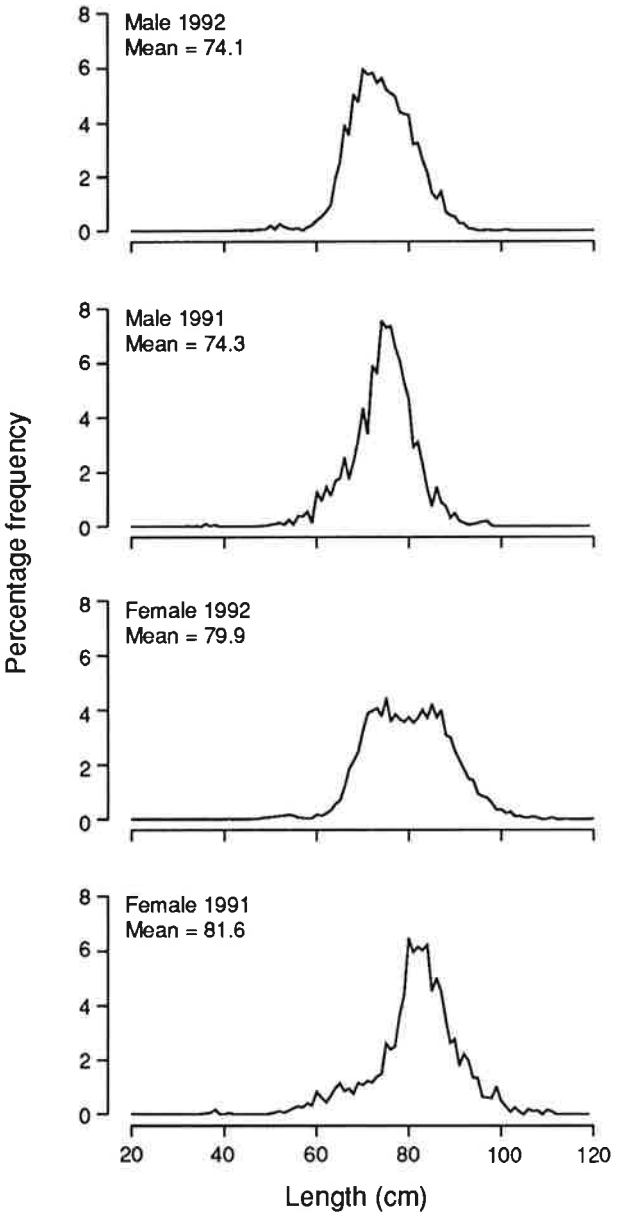

Figure 11: Total weighted length frequency distribution of male and female hoki taken from the Puysegur area.

female distribution was bimodal in 1992: the lower of the two modes probably reflects the appearance in the catch of many fish from the strong 1987 year class.

The hoki spawning season on the WCSI extends through July and August (Sullivan & Cordue 1992). In 1992, spawning hoki (running ripe and spent fish) were found in the Hokitika Canyon from mid July, but at the same time mainly prespawning fish were taken in the Puysegur area (*see* Figure 9). Although three hoki were recorded as spent in early July at Puysegur, the rest were mainly ripening (stage 2). Only a few ripe fish (stage 3) were found in early July, but the proportion increased in the mid August 1992 samples.

Langley (1993) found that larger hoki spawned earlier on the WCSI and that the mean size of each stage decreased over the season in both sexes. His data indicated that turnover was occurring on the spawning grounds as the larger fish were replaced progressively by smaller fish. He proposed that hoki arrive on the spawning grounds as groups of prespawning stage 2 fish which then undergo synchronous maturation and spawning.

In the Puysegur area, the mean size of each stage increased over the spawning season, suggesting that different groups of fish were being sampled through the spawning season. The time between samples was too short for growth to account for the increasing mean size.

Smaller fish may move north to spawn on the WCSI. The 1987 year class dominated catches in the Puysegur area before appearing on the WCSI, suggesting that these fish may be migrating through the area. The Puysegur area may not be a major spawning ground. Perhaps only larger hoki which do not have enough time to reach the WCSI grounds within the spawning season spawn at Puysegur from mid August to early September.

It is unfortunate that in 1992 sampling stopped in the critical period when spawning was probably occurring. No samples were taken between 4 and 21 August. If this type of study is repeated, at least one vessel should continuously survey the area from mid or late June to mid September.

Acknowledgments

MAF Fisheries thank Vela Fishing Limited for the opportunity to extend the sampling programme to the Puysegur area and for their financial support of this joint study.

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