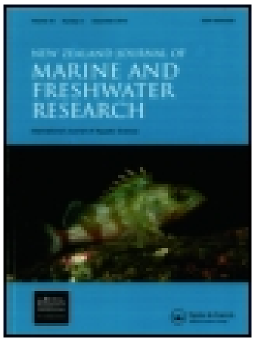

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Growth of tagged rock lobsters (*Jasus edwardsii*) near Stewart Island, New Zealand

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Abstract Annual growth, growth per moult, moult frequency, and moulting seasons were estimated for rock lobsters *Jasus edwardsii* tagged in three areas around Stewart Island. There were no significant differences in growth parameters between the areas within the size range 70–99 mm carapace length, although differences between Stewart Island and previously reported data from Gisborne were noted. There were significant differences in growth between the sexes. Females reached minimum legal size at about 6 years and sexual maturity at about 8 years after settlement. Males reached minimum legal size at just under 6 years.

Keywords Palinuridae; *Jasus edwardsii*; growth; moulting; tagging; Stewart Island

INTRODUCTION

The fishery for rock lobsters (*Jasus edwardsii*) around Stewart Island is an important component of the large fishery for this species in southern New Zealand. In 1981, 416 t (9%) and in 1983, 319 t (6.5%) of the total New Zealand rock lobster landings came from statistical area 924 around Stewart Island (Sanders 1983, 1984). As part of an investigation of the population dynamics and fishery for rock lobsters at Stewart Island a tagging programme was carried out between 1974 and 1980. This paper presents estimates of growth rates obtained from this programme.

In many field tagging studies of large commercially fished crustaceans severe constraints are placed on the type of data which can be obtained. The size range of animals available for tagging is usually narrow and recaptures are limited to those made during the fishing season. This study is no exception in that most of the data are for rock lobsters just below the minimum legal size. In addition, *Jasus edwardsii* in New Zealand shows a high degree of individual variability in growth rates (Street 1969; McKoy & Esterman 1981). These factors combine to prevent accurate estimates of size at a given age for individuals and it is difficult to produce growth curves which reliably predict growth rates for larger animals. However, estimates of growth rates (and variability in those rates) in the size ranges described in this and similar papers are valuable for estimating yield per recruit and for predicting age at entry to the fishery.

METHODS

Rock lobsters were caught either by diving (May 1977 and February 1978) or commercial potting (all other tagging) (Table 1) and tagged with western rock lobster tags (Chittleborough 1974) or Floy FTL6 (Sphyrion) tags. Details of tagging technique are as described by McKoy and Esterman (1981). Rock lobsters were released in several areas on the northern, eastern, and southern coasts of Stewart Island. Release areas are shown as shaded areas in Fig. 1.

Release sites (Fig. 1) were initially grouped into three major areas for the purposes of analysis. These areas were, West Ruggedy Beach to East Cape including the islands off Halfmoon Bay ('Halfmoon Bay'), East Cape to Kopeka River ('Lords River'), and South West Cape to Big Moggy Island ('South West Cape'). Animals which had moved from one area to another (McKoy 1983) were included in the data set for the area in which they were released.

Data recorded for each tagged animal included sex, state of sexual maturity (females only), carapace length, and damage. For recaptures, the same data were recorded together with the location and date of capture. Carapace length (CL) was measured from the antennal platform to the posterior dorsal margin of the carapace, along the midline. When possible, only undamaged rock lobsters were tagged and any which had lost more than two pereiopods or one antenna when tagged were excluded from the study.

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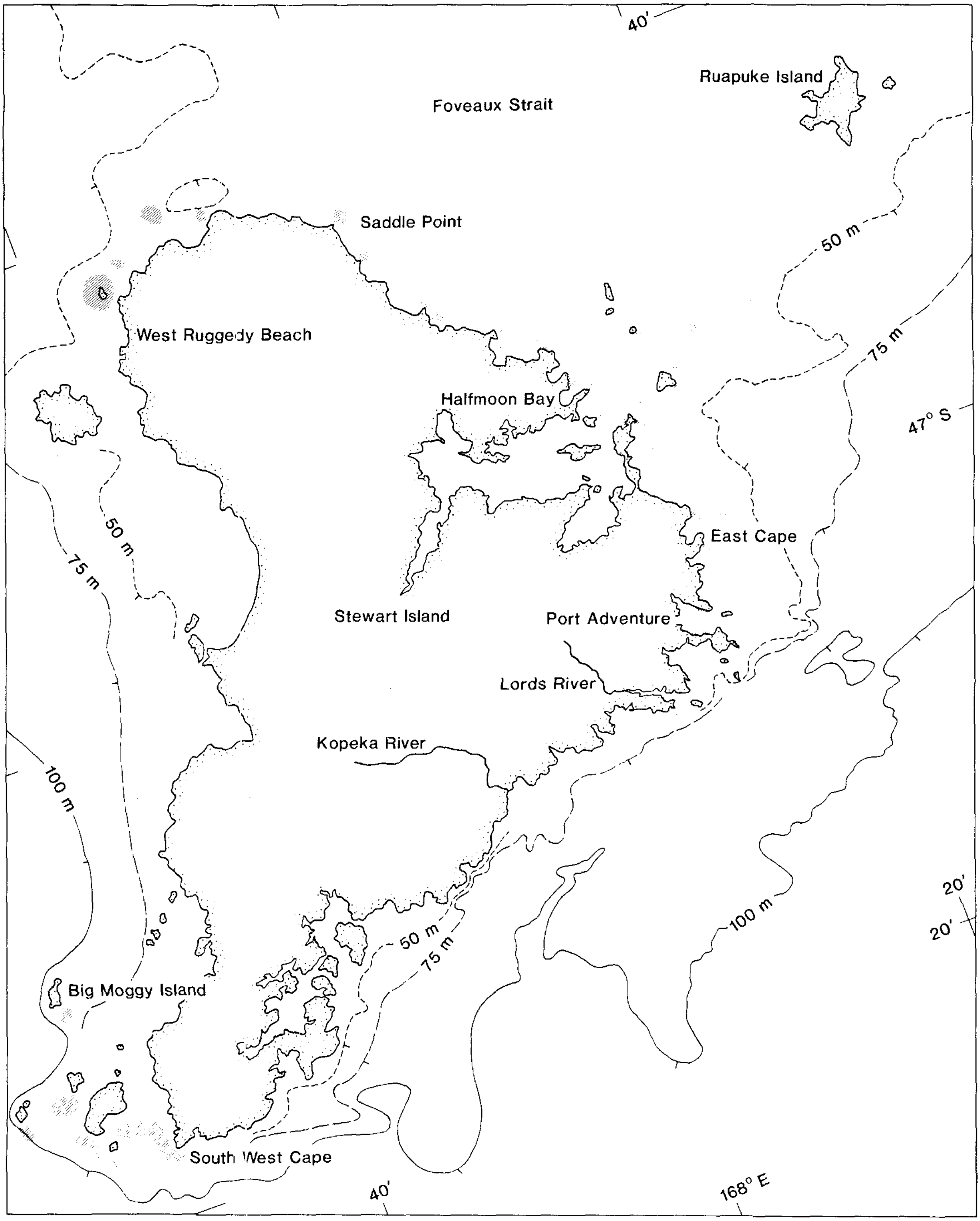


Fig. 1 Stewart Island, showing localities where tagged rock lobsters were released (shaded areas), and localities mentioned in the text.

Table 1 Areas and dates when rock lobsters (*Jasus edwardsii*) were tagged around Stewart Island, numbers tagged, and numbers recaptured with growth data.

Area and tagging date	Males No. tagged	Males No. recap.	Females No. tagged	Females No. recap.
Halfmoon Bay				
Nov 14–15 1974	16	6	19	1
Nov 4–10 1975	102	24	189	45
Aug 3–9 1976	192	78	185	69
Sep 20–22 1976	87	33	168	42
Nov 8–16 1976	56	22	133	33
May 27–30 1977	101	48	92	35
Aug 9–16 1977	290	79	362	65
Feb 20–23 1978	71	25	74	19
Total	915	315	1222	309
Lords River				
Aug 3–9 1976	401	193	298	123
Nov 8–16 1976	154	66	208	73
Aug 9–16 1977	226	103	219	86
Nov 9–10 1977	157	61	189	69
Total	938	423	914	351
South West Cape				
Nov 8–16 1976	161	46	243	55
Grand total	2014	784	2379	715

RESULTS

The numbers of rock lobsters of each sex tagged in each area, and the numbers from each group recaptured and for which growth data were available are shown in Table 1.

Size frequency distributions of the tagged rock lobsters for the combined releases in each area are shown in Fig. 2. Most rock lobsters fell within a narrow size range. Those < 70 mm CL were difficult to catch in pots. The minimum legal size is 152 mm tail length, which is equal to c. 96 mm CL for males and 92 mm CL for females. Because most tagging was carried out on commercial fishing boats, and legal sized animals were not purchased from fisherman for tagging, the number of larger animals available for tagging was very limited. The exception to this was ovigerous females, which are not legally takeable. These animals were, however, often recaptured during the egg-bearing season in the year following tagging and many fishermen were reluctant to return them. Most of the tagged female rock lobsters > 95 mm CL were mature (Fig. 2).

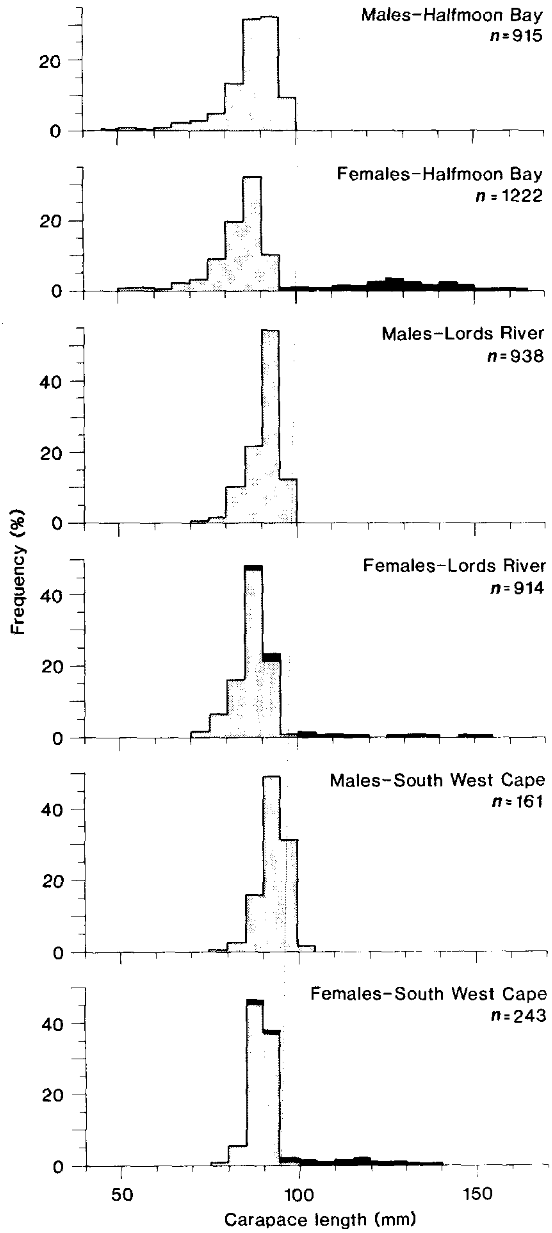


Fig. 2 Size frequency distributions of tagged rock lobsters in each area. All releases for each area are combined. Mature females shown in black.

Moulting seasons

Moulting seasons of rock lobsters between 80 and 99 mm CL were estimated using the method described by McKoy and Esterman (1981). Growth increments of recaptured animals, for each tagging date and area, were plotted against the number of days at liberty. Comparison of the numbers of rock lobsters which had not grown with the number which had grown in any particular time interval after tagging suggests seasonality in moulting. Examples of these plots are shown in Fig. 3. The

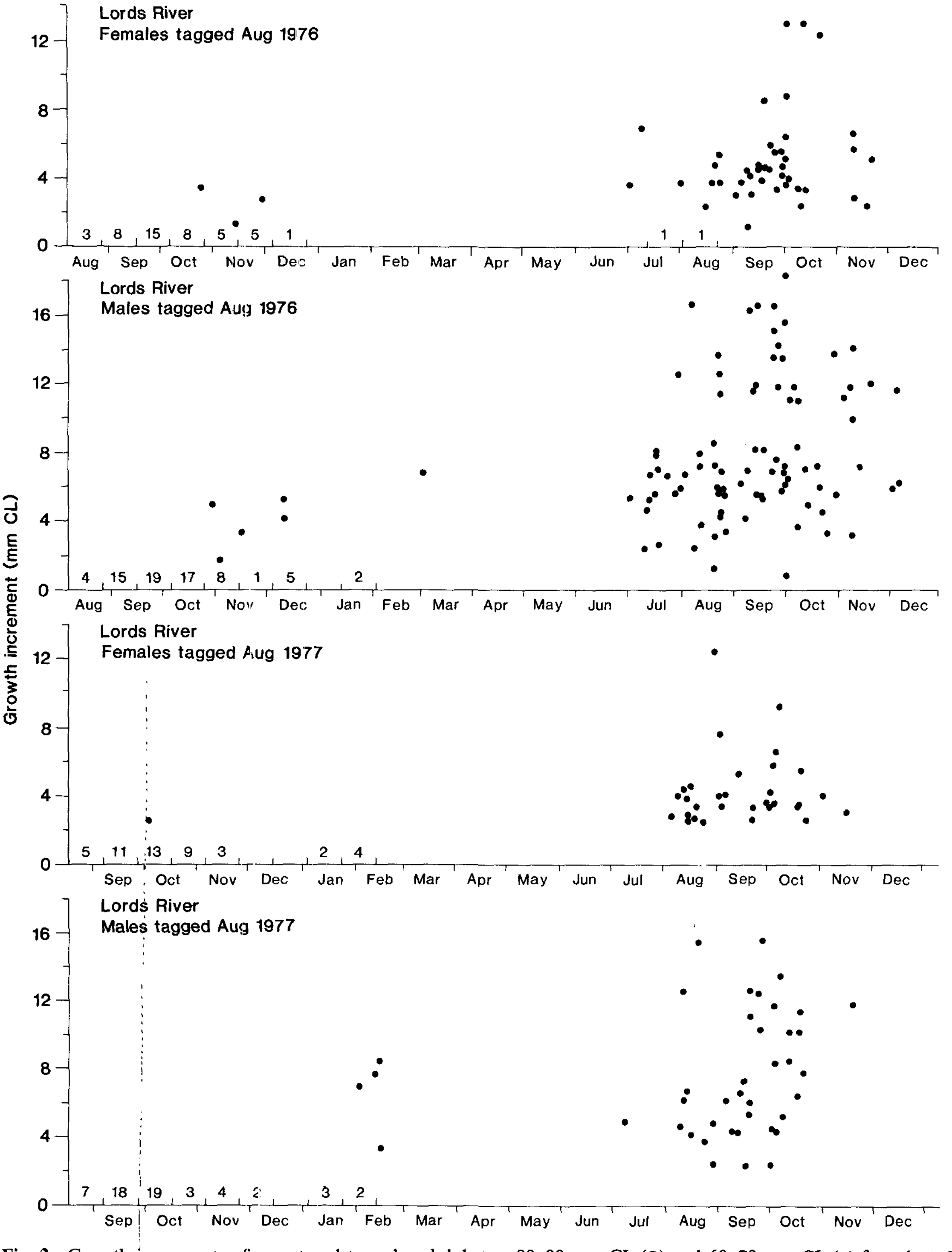


Fig. 3 Growth increments of recaptured tagged rock lobsters 80–99 mm CL (●) and 60–79 mm CL (x) for selected tagging periods and areas. Numbers of animals which had not grown at recapture are shown along the abscissa. All females in this data set were immature at tagging and recapture.

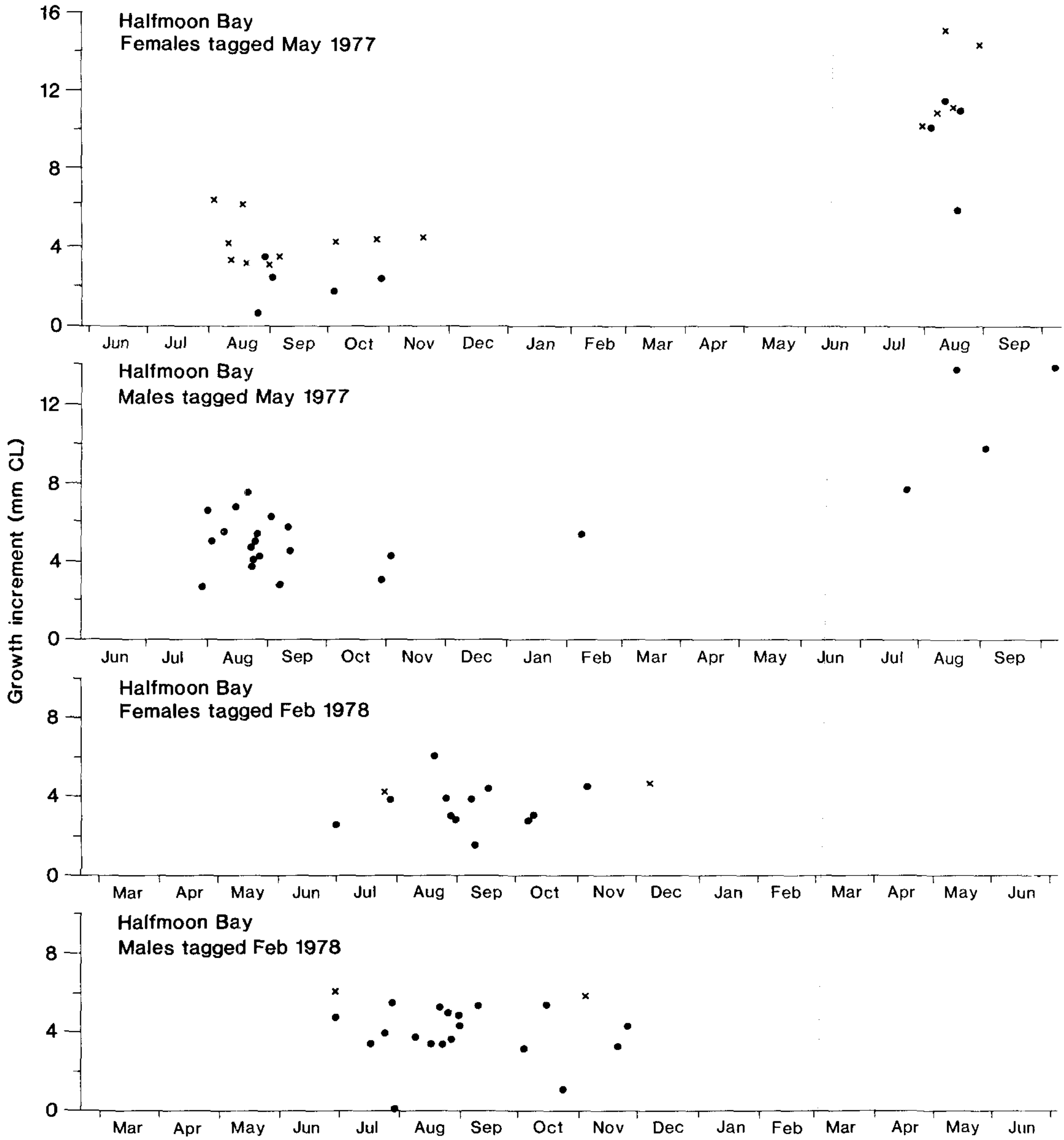


Fig. 3 (*Continued*)

catchability of rock lobsters is reduced for 3–4 weeks over the moulting period and some bias in estimating moulting seasons may be introduced when tagging is carried out close to a moulting period (McKoy & Esterman 1981). Consequently, recapture data from November taggings have not been used here to estimate moulting seasons. Plots for August taggings in the Halfmoon Bay area are very similar to those shown for Lords River. The recaptures, particularly from tagging at Lords River in August 1976 and 1977 and at Halfmoon Bay in May 1977 and February 1978 (Fig. 3), indicate that most rock lobsters of both sexes in the 80–99 mm CL size range, moulted in June–July, with some moulting again in November–January.

Some rock lobsters in the 60–79 mm CL size range were tagged in May 1977. The growth pattern of recaptured animals in this size group was similar

Table 2 Estimates of annual growth of *Jasus edwardsii* at Stewart Island based on tag-recapture data; all sizes and increments in mm CL; —, no data; s.d., standard deviation; *n*, sample size.

	Males				Females			
CL size class	*n*	Mean size at tagging	Mean increment	s.d.	*n*	Mean size at tagging	Mean increment	s.d.
70–74	—	—	—	—	1	74	10.8	—
75–79	5	77	10.0	3.8	14	78	5.9	2.7
80–84	24	82	9.4	3.9	31	83	5.4	2.6
85–89	30	88	6.7	3.5	65	87	4.0	1.6
90–94	62	92	6.1	2.9	28	91	4.0	1.5
95–99	8	96	4.8	1.4	2	98	4.1	1.8
> 100	—	—	—	—	6	130	1.6	2.0

Table 3 Parameters of the von Bertalanffy growth function for male and female *Jasus edwardsii* tagged near Stewart Island and for Gisborne Local males (from McKoy & Esterman 1981).

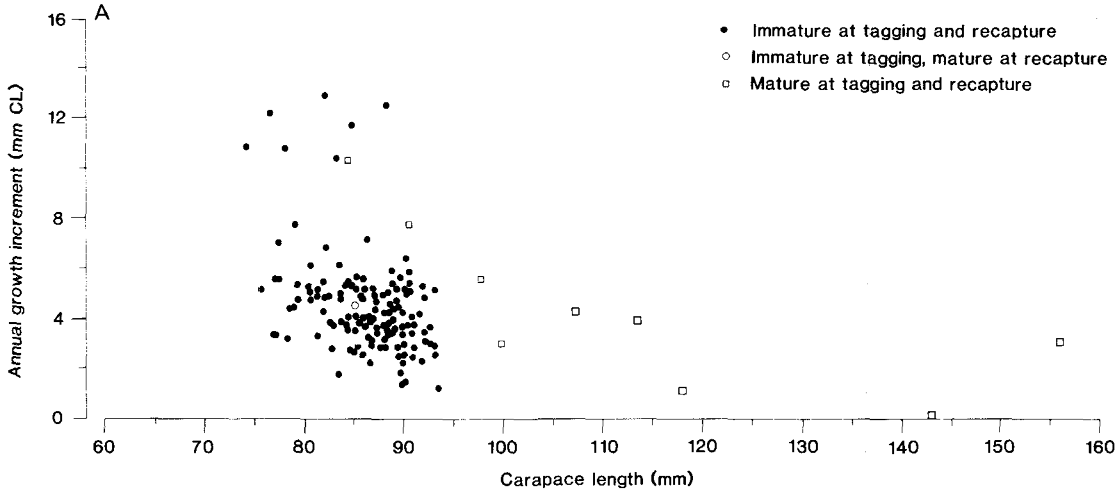
	Stewart Island Males	Stewart Island Females	Gisborne Local males
L_∞ (mm CL)	121	137	118
Standard deviation of L_∞ (mm CL)	5.9	4.6	5.8
K (per year)	0.26	0.17	0.29
Standard deviation of K	0.03	0.02	0.05
t_0 (years)	!0.36	!0.49	!0.36

Table 4 Results of Mann-Whitney U-tests comparing annual growth increments of rock lobsters in 10 mm size groups at Stewart Island with annual growth for similar size groups in three areas near Gisborne (from McKoy & Esterman 1981) (n.s., no significant difference; **, $P < 0.01$; *, $P < 0.05$; *n*, sample size; —, no data).

	n	Gisborne Local	*n*	South of Young Nicks Head	*n*	Mahia	*n*
Stewart Island females							
80–89 mm	96	**	5	—		**	21
90–99 mm	30	—		—		n.s.	13
Stewart Island males							
70–79 mm	5	n.s.	2	—		—	
80–89 mm	10	n.s.	10	n.s.	5	*	10
90–99 mm	70	n.s.	10	n.s.	23	**	8

to that for the 80–99 mm CL animals tagged at the same time and place (Fig. 3). These observations are generally consistent with those reported by Street (1969), who noted that 'medium' sized rock lobsters in eastern Foveaux Strait moulted in June–August and that the start of the fishing season (usually July–August) was associated with the beginning of post-moult feeding activity.

In the Gisborne area male rock lobsters between 80–99 mm CL moulted mainly in September–November, with some moulting a second time each year, between February and August (McKoy & Esterman 1981). Females in this size range in Gisborne appeared to moult only once each year, between December and July. Females of this size in Gisborne are sexually mature (Annala et al.



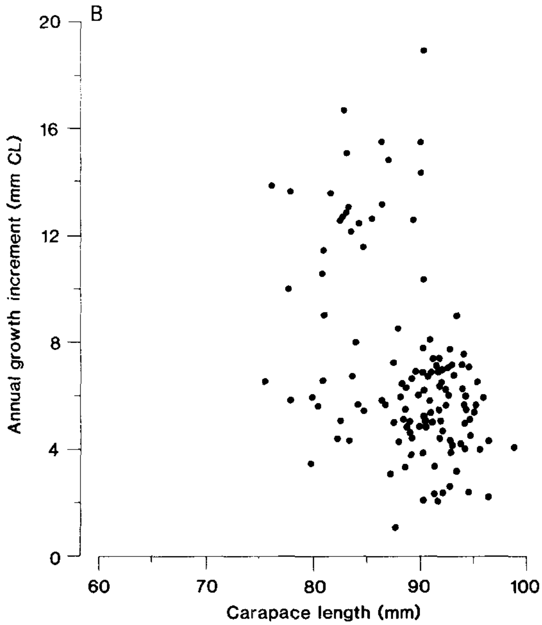


Fig. 4 Annual growth increments of **A**, female and **B**, male rock lobsters at Stewart Island as a function of carapace length.

1980), unlike those at Stewart Island. Their moulting pattern is more like the larger mature females in Otago and Southland, described by Street (1969) as moulting once per year in February–April.

Annual growth

Annual growth was estimated from the growth increments of rock lobsters recaptured on or near the anniversary of tagging, using the method of Hancock & Edwards (1967). For all sets of data the growth of animals recaptured between 330 and 390 days after tagging was assumed to represent annual growth. The presence of the tag was assumed to have no significant effect on annual growth (McKoy & Esterman 1981).

Annual growth estimates from each tagging period were combined within each area since the data were inadequate for comparisons between tagging periods. For 5 mm size groups within each sex with adequate data for comparisons there was no significant difference in annual growth between each of the tagging areas (Mann-Whitney U-test $P > 0.05$). Consequently, annual growth data from all areas were combined, within each sex, for further analysis (Table 2).

There were significant ($P < 0.01$) negative correlations between annual growth increment and carapace length at tagging for both sexes (Fig. 4). Within this size range there is a high level of variability of annual growth within any CL group.

A reasonable fit for regressions of annual growth increment (a) on CL for the size range covered for males was:

$$a = 35.0 - 0.316\,CL$$
($r = -0.436$, $n = 127$, CL range 75–98 mm).

The best correlation for females was obtained by regressing $l_n\,(a + 1)$ on CL such that:

$$a = e^{(3.76 - 0.024\,CL)} - 1$$
($r = -0.585$, $n = 145$, CL range 74–155 mm).

All recaptured females larger than 95 mm CL at tagging were mature, and most of those less than 95 mm CL were immature (Fig. 4).

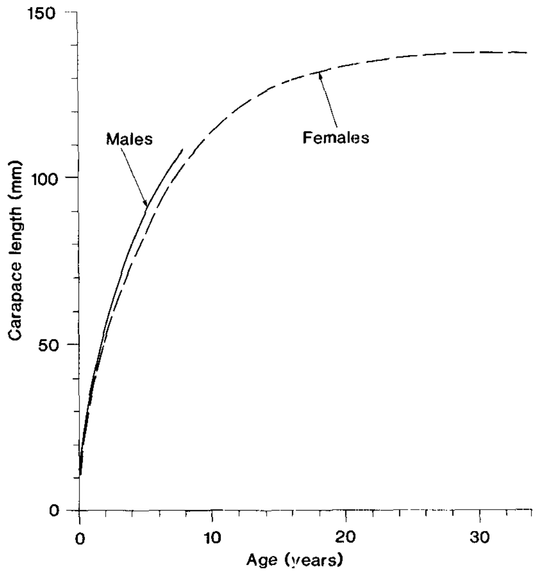


Fig. 5 von Bertalanffy growth curves for growth in carapace length of male and female rock lobsters at Stewart Island based on annual growth estimates from tagging and on juvenile growth estimates from Annala and Bycroft (1985).

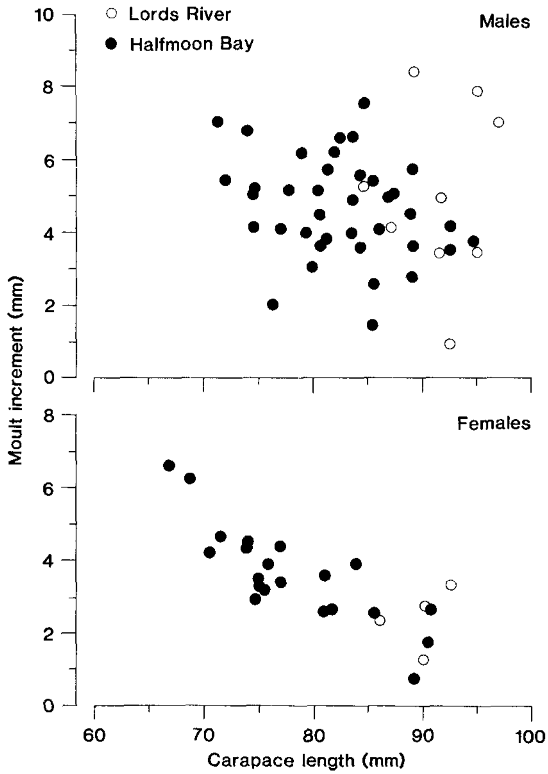


Fig. 6 Growth per moult of male and female rock lobsters at Stewart Island as a function of carapace length. All females were immature.

As a basis for estimates of age at entry to the fishery and age at sexual maturity, the combined data on annual growth from all areas and taggings were used to calculate the parameters of the von Bertalanffy function (Table 3) using Fabens' (1965) method. To avoid the destabilising effect of the mass of data points in the 75–99 mm CL size range, the parameters were calculated using mean values of annual growth in 5 mm CL size groups (Table 2). Values of annual growth of juveniles for 1982 from Annala & Bycroft (1985) were also incorporated. For females, the 6 data points for animals larger than 100 mm CL at tagging were included separately. No males larger than 100 mm CL at tagging were returned and the curve has no predictive value outside the range of the data points included.

The resulting growth curves (Fig. 5) suggest that female rock lobsters at Stewart Island reach the legal size (152 mm tail length, about 92 mm CL) at about 6 years after settlement. Mean size at the onset of the sexual maturity (generally at about 107 mm CL, see Annala et al. 1980) is reached at about 8 years of age. Males appear to grow slightly faster than females and reach the legal size (around 96 mm CL) at just under 6 years old. The parameters of the curve for male rock lobsters at Stewart Island are very close to those cited for the 'Gisborne Local' area males by McKoy & Esterman (1981) (Table 3). Annual growth increments in 10 mm size groups (70–79.9, 80–89.9, 90–99.9) from Stewart Island were compared with those from Gisborne Local, South of Young Nicks Head, and Mahia from McKoy and Esterman (1981) where adequate data existed (Table 4). Mann-Whitney U-tests were used because of the non-normal distribution of annual growth increments in any one size group which resulted from some animals having moulted more than once. Within the size range tested, the growth rate of Stewart Island males was not significantly different from that of Gisborne Local or South of Young Nicks Head males, but it was significantly less than that of males at Mahia. The annual growth rate of Stewart Island females was significantly greater than that of Gisborne and Mahia females of 80–89 mm CL but not significantly different from that of Mahia females of 90–99 mm CL.

Estimates of the annual increase in weight of rock lobsters near the minimum legal size were made, based on the mean annual growth of males in the 95–99 mm size class, females in the 90–94 mm size class, and the length/weight relationship described

Table 5 Estimates of growth per moult of *Jasus edwardsii* at Stewart Island based on tag-recapture data, and t-test comparisons between sexes in each size group: all sizes and increments in mm CL; —, no data; s.d., standard deviation; *n*, sample size; n.s., not significant; *, significant $P < 0.05$.

	Males				Females				
CL size class	*n*	Mean size at tagging	Mean growth per moult	s.d.	*n*	Mean size at tagging	Mean growth per moult	s.d.	Comparison
65–69	—	—	—	—	2	67	6.3	1.8	
70–74	5	73	5.7	1.2	5	72	4.1	0.7	*
75–79	4	77	4.3	1.7	6	76	3.6	0.4	n.s.
80–84	16	82	5.0	1.3	4	82	3.1	0.6	*
85–89	11	88	4.3	1.8	4	88	1.7	0.9	*
90–94	4	92	3.2	1.6	4	91	2.6	0.7	n.s.
95–99	4	95	5.5	2.2	—	—	—	—	

Table 6 Estimates of annual moult frequency (mf) from annual growth (a) and single moult increment (i) where mf = a/i, for *Jasus edwardsii* at Stewart Island. s.d., standard deviation; —, no data.

Size class	Males		Females	
CL (mm)	mf	s.d.	mf	s.d.
75–79	2.3	0.54	1.6	0.21
80–84	1.9	0.19	1.7	0.22
85–89	1.5	0.23	2.3	0.65
90–94	1.8	0.41	1.5	0.21
95–99	0.9	0.19	—	—

by Annala and Bycroft (1985). The weight of females is increasing at about 14% per year and that of males at about 16% per year.

Growth per moult

Growth of rock lobsters recaptured within 182 days of tagging was assumed to represent one moult. The choice of the period of 182 days was based on the estimates of moulting seasons discussed above. Data from Lords River and Halfmoon Bay were combined within each sex, since a Mann-Whitney U test showed no significant difference in growth per moult between these areas in the 85–95 mm CL size group (for which comparable data were available). No data were available from South West Cape. Growth per moult for 5 mm CL size groups is shown in Table 5.

For males there was a high degree of variation in growth per moult for a given CL and no significant correlation between growth per moult and initial CL (Fig. 6). For immature females there was a highly significant negative correlation ($P < 0.01$) between growth per moult and original CL (Fig. 6). The relationship is:

Growth per moult $= -0.13$ CL $+ 14.0$
($r = -0.783$, $n = 23$).

Growth per moult of males was generally greater than for females but comparisons between males and females in each 5 mm CL size group indicated significant (t-test, $P < 0.05$) differences only for some size groups (Table 5).

The mean value of growth per moult of males between 70 and 99 mm CL was 4.7 mm, similar to the estimate of 5 mm for males between 70 and 116 mm CL in eastern Foveaux Strait reported by Street (1969).

Moult frequency

Mean annual moult frequency (Table 6) was estimated by dividing the mean annual growth (a) for each size group (Table 2) by the mean growth per moult (i) for that group (Table 5). The standard deviation of this ratio was estimated using the bootstrap technique described by Efron and Gong (1983).

The data on the seasonality of moulting presented above indicate that some animals of both sexes in the size range 60–99 mm moult twice per year. This is supported by the estimates in Table 6. In all size groups (except the 95–99 mm class for males) the mean annual moult frequency was at least 1.5. The estimated moult frequencies of males and females were similar, suggesting that differences in growth rate are mainly because of differences in growth per moult. The size range is too narrow and the variability in the data is too great to determine any trend in moult frequency with size.

DISCUSSION AND CONCLUSIONS

The observed growth of juvenile rock lobsters of both sexes at Stewart Island was generally slower than that of juveniles sampled at Gisborne (McKoy

& Esterman 1981; Annala & Bycroft 1985). However, within the size range for which most tagging data exist the annual growth rate of male rock lobsters at Stewart Island as described here is very similar to that of Gisborne males as reported by McKoy and Esterman (1981), although it is slower than that of males near Mahia Peninsula (Table 4). The level of individual variation was high in both areas. Similar variability has also been reported for *J. tristani* (Pollock & Roscoe 1977) and *J. lalandii* (Heydorn 1969). This tagging experiment did not include replacement and it was not possible to determine if animals with large annual increments during the release period continued to be fast growing.

Differences in the growth rate of females larger than 80 mm CL in the two areas are probably closely tied to the differences in the size at the onset of sexual maturity. Stewart Island females, which mature at around 105 mm CL, probably maintain an annual moult frequency greater than one for longer than the Gisborne females which are sexually mature at about 72 mm CL and which then moult once each year (McKoy & Esterman 1981). The Stewart Island data indicate, however, that some females may reduce their annual moult frequency to one well before they reach sexual maturity. It seems likely that a reduction to one moult per year is linked to the onset of sexual maturity, except in areas where the onset of maturity occurs at a large size, as at Stewart Island, where a reduction to one moult per year is determined by size.

The apparent similarities in growth rates between the three major areas around Stewart Island (Fig. 1) is in interesting contrast to the significantly different growth rates exhibited between similarly sized areas in Gisborne. Such differences presumably represent local variation in factors likely to influence growth rate, such as population density and food availability. Small scale local variations in growth rate at Stewart Island may have been obscured by the choice of relatively large areas for comparisons.

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REFERENCES

Annala, J. H.; Bycroft, B. L. 1985: Growth rate of juvenile rock lobsters (*Jasus edwardsii*) at Stewart Island, New Zealand. *New Zealand journal of marine and freshwater research 19*.

Annala, J. H.; McKoy, J. L.; Booth, J. D.; Pike, R. B. 1980: Size at the onset of sexual maturity in female *Jasus edwardsii* (Decapoda: Palinuridae) in New Zealand. *New Zealand journal of marine and freshwater research 14*: 217–227.

Chittleborough, R. G. 1974: Development of a tag for the western rock lobster. *CSIRO Division of Fisheries and Oceanography report 56.*

Efron, B.; Gong, G. 1983: A leisurely look at the bootstrap, the jackknife, and cross-validation. *The American statistician 37*: 36–48.

Fabens, A. J. 1965: Properties and fitting of the von Bertalanffy growth curve. *Growth 29*: 265–289.

Hancock, D. A.; Edwards, E. 1967: Estimation of annual growth in the edible crab (*Cancer pagurus* L.). *Journal du Conseil Permanent International pour l'Exploration de la Mer 31*: 246–264.

Heydorn, A. E. F. 1969: The rock lobster of the South African west coast *Jasus lalandii* (H. Milne-Edwards). 2. Population studies, behaviour, reproduction, moulting, growth and migration. *Investigational report, Division of Sea Fisheries, South Africa no. 71.*

McKoy, J. L. 1983: Movements of rock lobsters, *Jasus edwardsii* tagged near Stewart Island, New Zealand. *New Zealand journal of marine and freshwater research 17*: 357–366.

McKoy, J. L.; Esterman, D. B. 1981: Growth of rock lobsters (*Jasus edwardsii*) in the Gisborne region, New Zealand. *New Zealand journal of marine and freshwater research 15*: 121–136.

Pollock, D. E.; Roscoe, M. J. 1977: The growth at moulting of crayfish *Jasus tristani* at Tristan da Cunha, South Atlantic. *Journal de Conseil Permanent International pour l'Exploration de la Mer 37*: 144–146.

Sanders, B. M. 1983: The 1981 New Zealand rock lobster landings. *Fisheries Research Division occasional publication: data series no. 12.*

——— 1984: The 1983 New Zealand rock lobster landings. *Fisheries Research Division occasional publication: data series no. 16.*

Street, R. J. 1969: The New Zealand crayfish *Jasus edwardsii* (Hutton). *New Zealand Marine Department, fisheries technical report 30.*