SEASONAL DISTRIBUTION AND MOVEMENTS OF THE PADDLE CRAB *OVALIPES CATHARUS* IN CANTERBURY COASTAL WATERS

T.A. OSBORNE

Department of Zoology, University of Canterbury,
Christchurch, New Zealand.

ABSTRACT

Distributional patterns of the paddle crab *Ovalipes catharus* were studied at two locations in the Canterbury region. Little Akaloa is a sheltered, confined bay characterised by high crab abundance in winter and low abundance in summer. Pegasus Bay has a long exposed coastline and crabs are more abundant in summer than winter. Movements of crabs between the two areas appear to occur in relation to moulting and breeding cycles. Males and females aggregate and mate in Little Akaloa Bay during winter at the time of the female moult. Males probably moult after mating and when the females have left the bay. Males move into Pegasus Bay at the end of spring in search of better foraging areas whereas females migrate to spawning grounds which are possibly offshore in deeper water.

KEYWORDS: abundance, seasonal variations, migration, swimming crabs.

INTRODUCTION

The paddle crab, *Ovalipes catharus* (White, 1843), has been recorded from Northland to Stewart Island and at Chatham Island. It occurs off surf beaches and in estuaries and harbours, mainly on sandy bottoms (Stead, 1983). Armstrong (1986) and Stead (1983) both found that the abundance of *O.catharus* varied seasonally and that catches were highest off surf beaches in summer. In contrast, reports from fishermen and my own observations indicate that *O.catharus* is most abundant in winter in sheltered harbours and bays. In a laboratory study, I found that 74% of adult crabs moulted between June and November, and a field study has shown that females mate immediately after moulting in winter and spawn predominantly between November and March (Osborne, 1987). The results of tagging experiments led Wear (1982) and Stead (1983) to suggest that *O.catharus* is a highly migratory species and if so the high abundance of crabs in bays and harbours during winter and off surf beaches in summer may be the result of migrations which occur in relation to breeding and moulting cycles.

Habitat partitioning between adult and juvenile portunid crabs has been reported in other studies (Darnell, 1959; Klein Breteler, 1976; Hill et al, 1982; Potter et al, 1983) and adults are known to move between different habitats in relation to moult stage (Hines et al, 1987) and breeding cycle (Cargo, 1958; Hill, 1975; Norse and Fox-Norse, 1977; Paul, 1982; Potter et al, 1983). The present study was conducted at two locations in the Canterbury region, Little Akaloa Bay which is a shallow, sheltered bay on Banks Peninsula and Pegasus Bay which has an expansive, exposed shoreline. The aim of the study was to investigate distribution patterns of *O.catharus* in relation to size, moulting and breeding cycles, and possible seasonal migrations.

METHODS

The population of *O.catharus* at Little Akaloa Bay (Fig.1) was sampled on 22 occasions between January 1984 and December 1985. Crabs were caught using lift pots 80x80cm with a bottom of galvanised steel mesh (24 mm) and sides of nylon netting (mesh size 10 mm). The pots were baited with filleted fish frames, usually red cod or tarakihi, and set for 30 minutes at a time. After 2 or 3 sets, the pots were rebaited. The number of pots used and the number of sets per day varied from month to month but catch per unit effort was calculated for each month as the total number of crabs caught divided by the product of the number of pots and the number of 30 minute sets.

The pots were effective at catching crabs larger than 30 mm carapace width (CW); smaller crabs were caught by towing a 2 m beam trawl (mesh size 10 mm). On most occasions, two or three 15-minute trawls were done but either outboard motor failure or bad weather prevented the use of the trawl on five occasions: January, July, August and November 1984 and November 1985. During three trips, only the trawl was used (March and April 1984, September 1985) and as a result smaller samples were obtained. When only one sampler was used the size range of crabs was not necessarily complete (see Figs. 2 & 3).

Crabs were caught in lift pots at Little Akaloa Bay for a mark recapture experiment. Crabs that were active and had no more than two missing limbs were tagged as described by Osborne (1987) and released. Most recaptures were made during regular sampling trips or tagging trips and all recaptured crabs were measured and released again. Eight tagged crabs were returned from Little Akaloa Bay by amateur fishermen in response to a poster advertising the experiment.

The population of *O.catharus* in Pegasus Bay was sampled in the area shown in Fig.1. Crabs were caught on nine occasions, between June 1984 and May 1985 using an otter trawl with a cod end of mesh size 25 mm. Two or three 20-30 minute trawls were made each time and catch per unit effort was calculated as the total number of crabs caught, divided by the number of trawls.

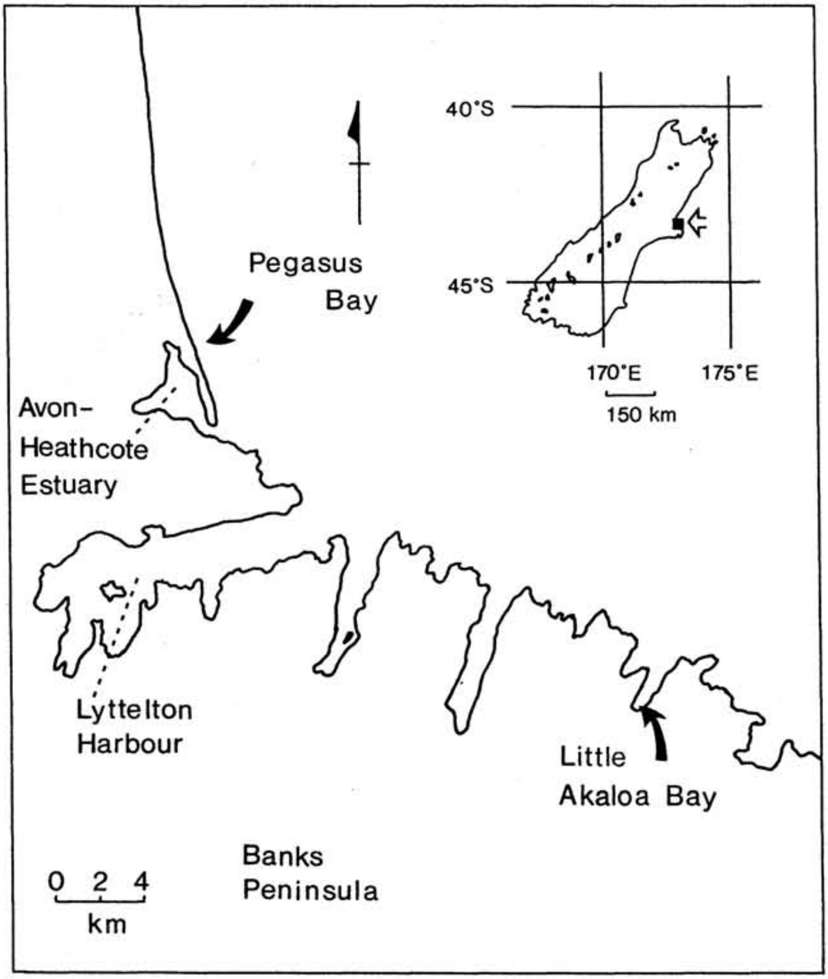

Fig.1. Northern side of Banks Peninsula; arrows indicate sampling sites at Little Akaloa Bay and Pegasus Bay.

RESULTS

LITTLE AKALOA BAY POPULATION

Size frequency distributions of male and female *O.catharus* from Little Akaloa Bay 1984 are shown in Fig. 2. Throughout the year the population consisted of two main cohorts. Individuals of cohort 1 had carapace widths of 35-60mm in January and had grown to 75-90mm CW by December. Individuals of cohort 2 entered the benthic population predominantly in March. However, they were not caught again in appreciable numbers until December, by which time they had grown to 40-60mm CW. Fig. 3 shows the size frequency distributions of male and female crabs from the same population in 1985. Few individuals belonging to cohort 1 were present after December and it is probable that large numbers of this cohort had migrated out of the bay. Cohort 2 (the March '84 recruits) increased in numbers and its members

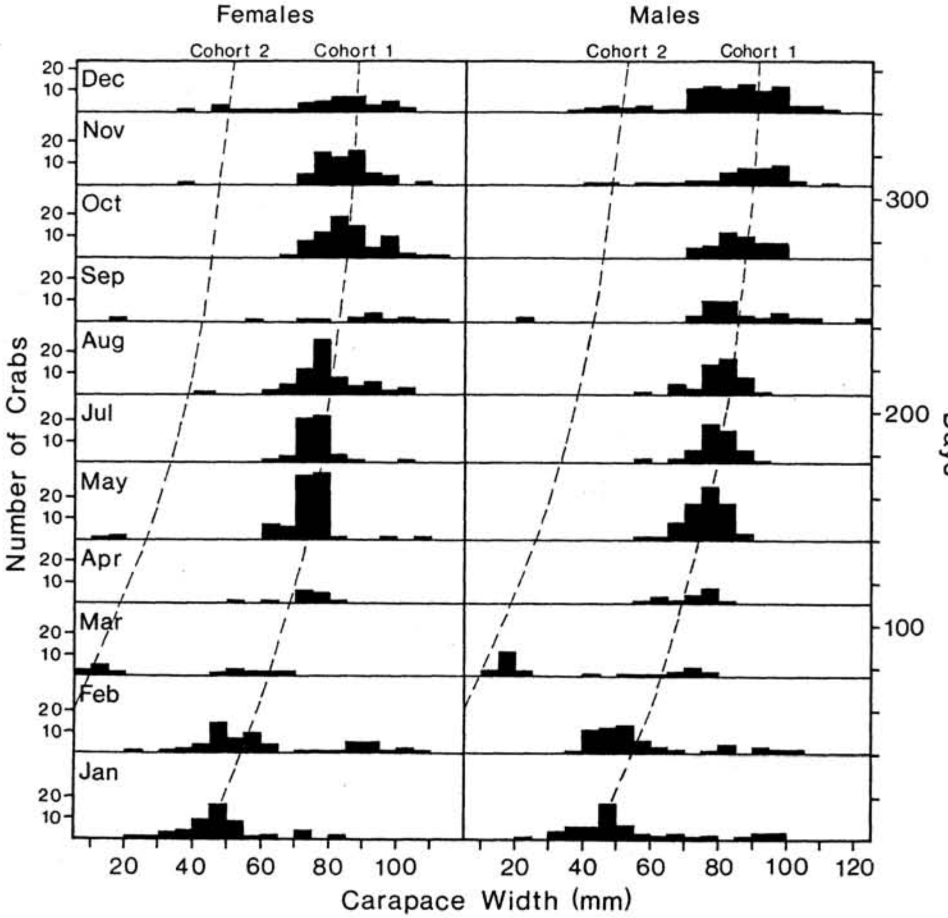

Fig.2. *Ovalipes catharus.* Monthly size frequency distributions of crabs caught at Little Akaloa Bay in 1984. Dashed lines indicate probable progression in size of separate cohorts.

grew larger in the first half of 1985; after August this cohort too declined in abundance. As in the previous year, March 1985 saw recruitment to the population of small individuals (cohort 4) that were not seen again in appreciable numbers until December. The main difference in population structure between the two years was the appearance of a large recruitment group in January 1985 (cohort 3) the equivalent of which was not observed the previous year. Cohort 3 was present throughout the year and its members had grown to 65-85mm CW by December.

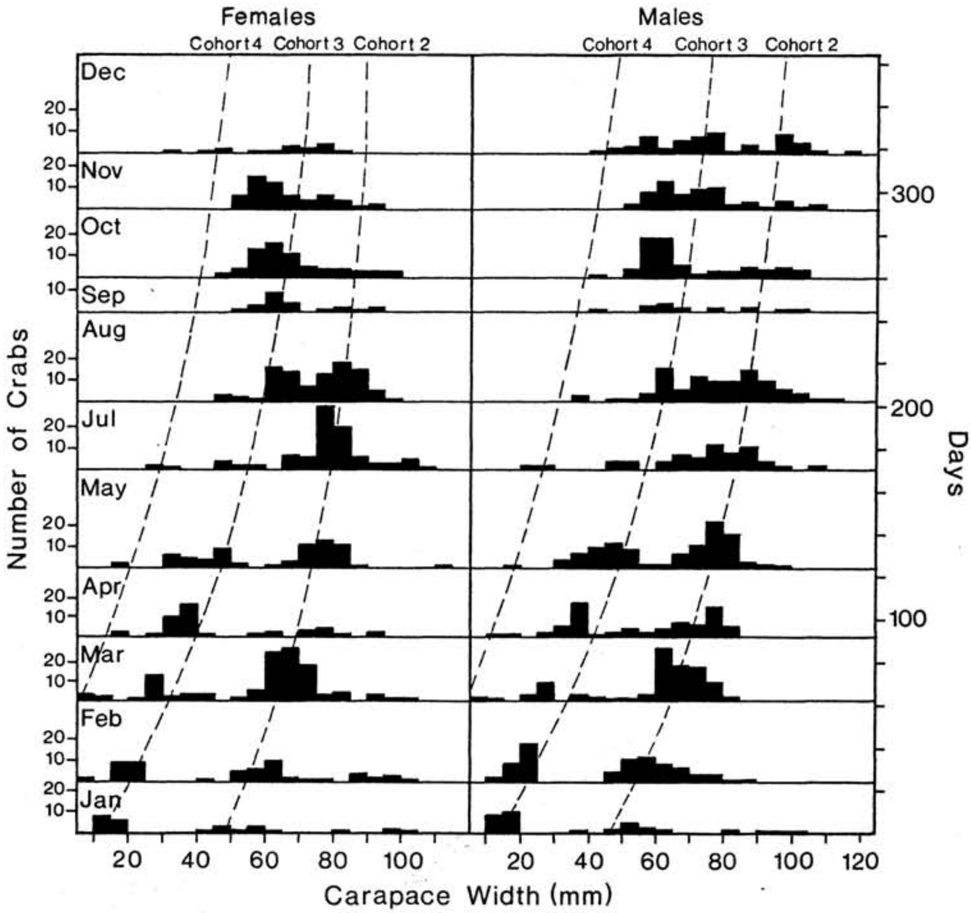

Fig.3. *Ovalipes catharus.* Monthly size frequency distributions of crabs caught at Little Akaloa Bay in 1985. Dashed lines indicate probable progression in size of separate cohorts.

To summarise, the population of crabs in Little Akaloa Bay consisted of four recognizable cohorts in 1984-85. Cohort 1 probably entered the population in about March 1983 and most of its members appeared to have migrated out of the population by January 1985. Cohort 2, the March '84 recruits, appeared to be segregated from the adult population during juvenile life but was present in the sampling area from December 1984 to August 1985 after which its numbers declined. Members of cohort 3, the January '85 recruits, provided no indication of habitat segregation during their juvenile life but instead were present in the sampling area from the time of settlement through to attainment of adult size. However, their numbers also declined at the end of the year. Cohort 4, the March '85 recruits, showed the same pattern as its counterpart from the year before in being absent from the sampling area during most of juvenile life.

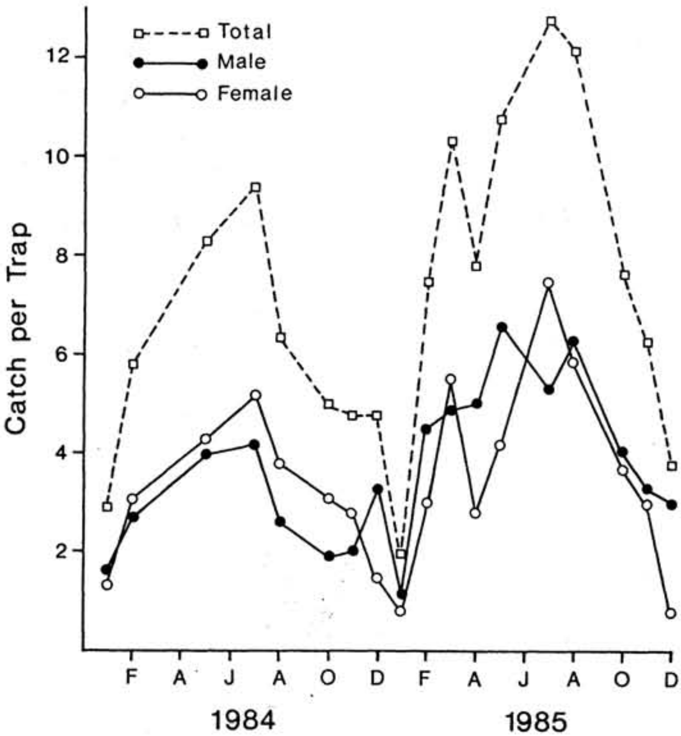

Fig.4. *Ovalipes catharus.* Catch per unit effort at Little Akaloa Bay 1984-85.

The pattern of increasing abundance in the first half of the year and declining abundance in the second half of the year is shown clearly in Fig. 4. Abundance (numbers of crabs per trap) was maximal in winter and minimal in summer, and was slightly higher in 1985 than 1984 when recruitment was greater.

Further evidence of crab migrations was obtained from a mark recapture experiment. Between January 1984 and January 1985 a total of 2657 crabs were tagged and released at Little Akaloa Bay (Table 1). At intervals between February 1984 and December 1985, 343 tagged crabs were recaptured. Most of the crabs that were recaptured had been tagged and released before October 1984 (97%). The low percentage of recaptures of crabs that were tagged and released between October and December 1984 supports the contention that they migrated out of the population shortly after their release. The few crabs that were tagged in January 1985 may not have joined the general outward migration as 25% of them were recaptured one month later.

Most crabs were recaptured from July to December 1984 and a few were taken during the equivalent period in 1985 (Fig. 5). This suggests that at least some crabs that had migrated out of Little Akaloa Bay returned the following winter. Of the 11 tagged crabs which returned to the population in 1985, all were males and only two had moulted since being released.

Table 1. Numbers of tagged crabs released between January 1984 and January 1985 at Little Akaloa Bay and number subsequently caught.

Months	No. of releases	No. subsequently caught	% subsequently caught
Jan	128	12	9.4
Feb	37	4	10.8
May	92	7	7.6
Jun	544	97	17.8
Jul	1050	138	13.1
Aug	96	14	14.6
Sep	449	62	13.8
Oct	84	1	1.2
Nov	86	4	4.7
Dec	83	2	2.4
Jan	8	2	25.0
Total	2657	343	

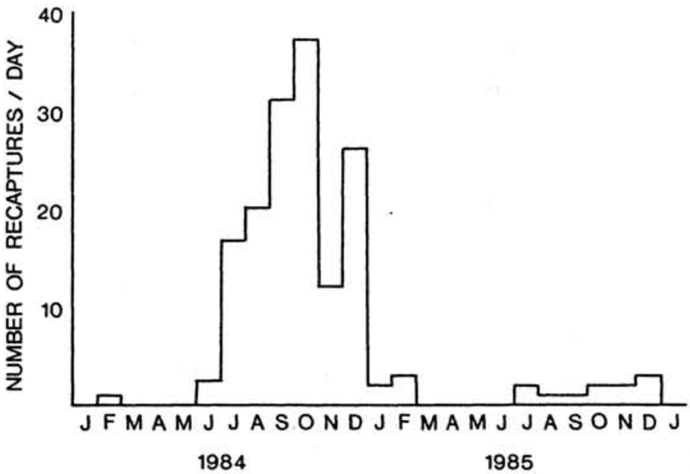

Fig.5. *Ovalipes catharus.* Number of tagged crabs recaptured per day at Little Akaloa Bay 1984-85.

PEGASUS BAY POPULATION

The relative abundance of male and female crabs in Pegasus Bay from June 1984 to April 1985 is shown in Fig. 6. Abundance of male crabs was maximal in summer and minimal in winter whereas numbers of females increased only slightly in spring and early summer and declined again in mid summer. Although the sampling program was not long enough to demonstrate a cyclical pattern of seasonal abundance, reports from local fishermen that crab catches tend to be high in summer and low in winter indicate that such a pattern does exist. The increase in abundance of males at Pegasus Bay coincided closely with the decline in abundance of males at Little Akaloa Bay. This suggests that male crabs migrate from sheltered, confined bays on to expansive, high wave energy beaches in spring.

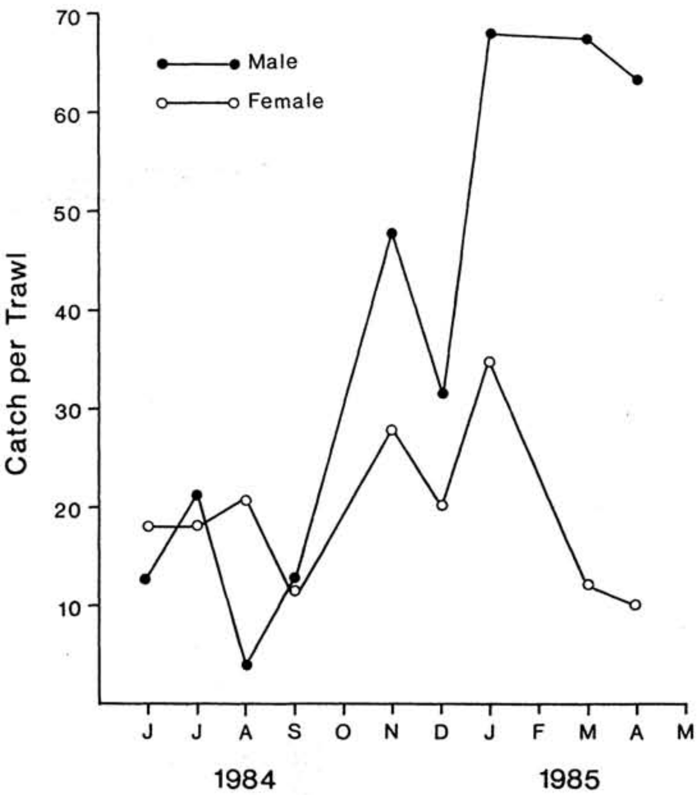

Fig.6. *Ovalipes catharus.* Catch per unit effort at Pegasus Bay from June 1984 to April 1985.

On the other hand, the summer decline in female abundance at Little Akaloa Bay corresponded with only a small and temporary increase in abundance in Pegasus Bay. The relatively low abundance of female crabs in both areas during the summer months corresponds with the period of egg-bearing in the Canterbury region. The few ovigerous females collected during the two sampling programs, especially in Pegasus Bay (Table 2) suggests that females may aggregate in shallow areas outside of those sampled or perhaps in deeper waters. On one occasion (January 1986), 20 out of 28 (71%) female crabs caught close to shore in Pegasus Bay in a fisherman's set net were carrying eggs, but the fisherman considered this unusual and took only 9 more ovigerous females during the rest of the summer. His observations suggest that wherever ovigerous females aggregate, it is not far from the rest of the population and occasionally they may intermingle.

Table 2. Numbers and percentage of adult females ($\geq$65 mm CW) and ovigerous females in 7 samples from Little Akaloa Bay (LA) and Pegasus Bay (PB).

Samples	No. of females (% of total adults)	No. of ovigerous females (% of total females)
LA Jan '84	6 (32%)	1 (17%)
LA Feb '84	17 (55%)	1 (6%)
LA Nov '84	59 (60%)	2 (3%)
PB Nov '84	14 (19%)	3 (21%)
LA Dec '84	34 (31%)	3 (9%)
LA Jan '85	4 (44%)	1 (25%)
PB Jan '85	24 (24%)	2 (8%)

DISCUSSION

DISTRIBUTION OF JUVENILES

At times of high adult abundance in Little Akaloa Bay, juvenile crabs appeared to occupy habitats other than those of the adults. In March of both years, evidence of recruitment of newly settled crabs into the population was obtained but small crabs were caught in trawls only occasionally during winter and spring. By December, when adult abundance had declined, members of the March recruitment cohort had increased in abundance in the areas trawled. Wear and Haddon (1987) reported a high level of cannibalism in *O.catharus*, and noted that it accounted for as much as one third of the diet at some localities. In the laboratory, the risk of cannibalism increased as the size differential between individuals increased (pers. obs.) although all crabs were vulnerable at ecdysis. Gotshall (1978) suggested that the presence of large numbers of adult *Cancer magister* may restrict survival of an incoming year class because of foraging on juveniles by adults. Such a situation could occur in *O.catharus*, and juveniles may seek refuge from cannibalism by occupying a different habitat.

Segregation of habitat between adults and juveniles has been found in the portunids, *Callinectes sapidus* (Darnell, 1959) and *Portunus pelagicus* (Potter et al, 1983) whose juveniles occur in shallower waters than adults. In *Carcinus maenas* (Klein Breteler, 1976), *Scylla serrata* (Hill et al, 1982) and the cancrid crab *Cancer irroratus* (Krouse, 1976), juveniles reside in intertidal areas seeking shelter in small creeks, pools, under stones and in seagrass or mangrove beds whereas adults occur in subtidal areas.

The cohort of newly settled *O.catharus* which appeared in the Little Akaloa population in January 1985 did not seek shelter elsewhere but remained in the sampled area throughout the year. This may have been because settlement occurred during a period of low adult abundance when the threat of cannibalism was low.

DISTRIBUTION AND MOVEMENTS OF ADULTS.

Throughout autumn and winter at Little Akaloa Bay, crab abundance was very high. So high in fact that it is hard to imagine the food supply being great enough to support the population. In a dietary study of *O.catharus*, Davidson (1987) found that during winter feeding activity at Little Akaloa was generally lower than in other seasons but still relatively high. However, a large proportion of the diet of adult crabs was algae (42%) and decapods (37%) which are less preferred foods than bivalves (9%), fish (1%) and small soft-bodied crustaceans (4%). In contrast, adult crabs at two locations in Pegasus Bay throughout the year were feeding predominantly on bivalves (17% and 64%), fish (24% and 15%) and crustaceans (predominantly mysids) (53% and 15%), and only small amounts of Decapoda and algae.

There must be a reason for *O.catharus* aggregating in Little Akaloa Bay during winter under suboptimal foraging conditions, and one possibility is that it is associated with moulting and mating of adults which takes place at that time of year (Osborne, 1987). Moulting under crowded conditions does not appear to provide any obvious advantage to males which are very vulnerable to cannibalism during ecdysis, but females mate immediately after moulting and would be protected by their mates. Therefore, males and females aggregating during the female moulting season could ensure an adequate supply of large mates for females. Sloan (1985) found that king crabs (*Lithodes aequispina*) were distributed at different depths according to sex, but that males and females aggregated at a particular depth during the mating season. Hines et al (1987) found that premoult female *Callinectes sapidus* did not occur in the areas where premoult males aggregated but instead moulted in areas where intermoult males were abundant. They also found that males aggregated in sheltered, low salinity creeks to moult and the reasons they suggest for this may be applicable to the *O.catharus* situation in Little Akaloa Bay.

Firstly, aggregating in sheltered areas for moulting may minimize mortality due to predation and cannibalism during the vulnerable period surrounding ecdysis. Although intermoult crabs readily attack soft crabs, late premoult and early postmoult crabs cease feeding and therefore, would not be a threat to each other. Furthermore, it is likely that as in the creek where *C.sapidus* were found moulting, the shallow water at the head of Little Akaloa Bay is relatively free of fish large enough to feed on large, soft crabs.

Secondly, Hines et al (1987) found that although not actively feeding, early, postmoult *C.sapidus* frequently consume their exuviae in the laboratory, presumably to provide minerals required for recalcification of the exoskeleton. If crabs are frequently separated from their exuviae before feeding in the field, moulting aggregations would make it easy to find another exuviae nearby. It is generally accepted that males need to be hard-shelled in order to mate (Lipcius, 1985), and several authors have reported male crabs moulting before females and therefore being hard-shelled in time for mating (Penn, 1977; Conan, 1985; Lipcius, 1985). Surprisingly, therefore, adult male *O.catharus* kept in the laboratory moulted slightly later than females (pers. obs.) and at Little Akaloa Bay, females leave the population in spring slightly earlier than males which suggests that males may wait until after mating and emigration of females before moulting themselves.

The gradual decline in abundance of *O.catharus* at Little Akaloa Bay after July indicates that after moulting, crabs leave the population possibly in search of better foraging areas. If crabs move from Little Akaloa Bay to Pegasus Bay in spring, they would be joining a population that is foraging more actively according to the scale of foregut fullness used by Davidson (1987). The increase in abundance of male crabs in Pegasus Bay in spring, therefore, would seem to result from the movement of crabs from sheltered bays and estuaries like Little Akaloa Bay.

The whereabouts of adult female *O.catharus* during the warmer months (including the egg-bearing season) is, as yet, unknown. After mating, they leave shallow, protected areas like Little Akaloa Bay but unlike males they do not reappear in Pegasus Bay. There are three possible explanations for the absence of ovigerous females from either sampling area. It is possible that ovigerous females may become inactive and cease feeding in which case they would not be caught by trawls or baited traps. The tendency for ovigerous females to behave in this way has been reported in the fiddler crab, *Uca pugilator* (Colby and Fonseca, 1984) and the cancrid, *Cancer pagurus* (Howard, 1982). However, such behaviour has not been reported previously in portunid crabs for which sparse abundance of ovigerous females within a population is usually attributed to spawning migrations (Cargo, 1958; Hill, 1975; Norse and Fox-Norse, 1977; Sasaki and Kawasaki, 1980; Paul, 1982; Potter et al, 1983). In the laboratory, ovigerous *O.catharus* exhibited no reduction in activity or feeding (pers. obs.) and Davidson (1987) found that most of the ovigerous females he examined had been feeding recently.

Alternatively, females may aggregate in shallow areas away from the main population and more extensive sampling should identify these areas. Examples of such behaviour have been provided by Park (1969) who reported a dense aggregation of ovigerous females of the portunid *Cronius tumidulus* in an area separate fom the rest of the population in Biscayne Bay, Florida, and Norse and Fox-Norse (1977) who found ovigerous females of the pelagic portunid *Euphylax dovii* aggregating in shallow waters well away from the oceanic habitat of the rest of the population. Females of several other portunid crabs inhabiting brackish waters make spawning migrations into higher salinity waters (Cargo, 1958; Hill, 1975; Paul, 1982; DeVries et al, 1983; Potter et al, 1983) which are associated with the higher salinity requirements of eggs and larvae (Costlow and Bookhout, 1959; Sandoz and Rogers, 1944; Hill, 1974).

Finally, it is possible that females migrate offshore into deeper, stiller water to incubate their eggs in the manner of *Cancer pagurus* (Howard, 1982), *Ovalipes punctatus* (Sasaki and Kawasaki, 1980), *Portunus pelagicus* (Smith, 1982), and the king crab *Lithodes aequispina* (Sloan, 1985). The adaptive significance of such offshore migrations might be related to enhancing larval retention in certain areas e.g. fiords (Sloan, 1985) or enhancing larval survival in the food rich, planktonic environment of offshore waters (Smith, 1982). Except for the final megalopal stage, the larvae of *O.catharus* are rarely found in inshore waters and it is presumed that they live offshore in deeper water (Wear and Fielder, 1985). I consider this to be the preferred explanation of the distribution of ovigerous *O.catharus*, but because a few ovigerous females were caught within Pegasus Bay it seems likely that females are not moving far away to spawn and under certain conditions may reunite with the rest of the population.

More extensive sampling of deep and shallow areas, and a detailed study of the distribution of early larval stages may help to answer the question of female movements and spawning behaviour.

ACKNOWLEDGEMENTS

Thanks go to my supervisors Colin McLay and Mike Winterbourn for their assistance in preparing this manuscript and to Dave Tattle whose boathandling skills made sampling at Pegasus Bay possible. Very special thanks to Dave Leathwick and all the others who assisted with the sampling and tagging programs at Little Akaloa Bay. This study was made possible by a research grant from Fisheries Research Division, Ministry of Agriculture and Fisheries.

LITERATURE CITED

ARMSTRONG, J.H. 1986. Paddle crabs in Otago waters - a possible fishery? *Catch 13(11)*: 19-20.

CARGO, D.G. 1958. The migration of adult female blue crabs, *Callinectes sapidus* Rathbun, in Chincoteague Bay and adjacent waters. *Journal of Marine Research 16*: 180-191.

COLBY, D.R & FONSECA, M.S. 1984. Population dynamics, spatial dispersion and somatic growth of the sand fiddler crab *Uca pugilator*. *Marine Ecology Progress Series 16*: 269-279.

CONAN, G.Y. 1985. Periodicity and phasing of molting. In: Crustacean Issues 3: Factors in adult growth. A.M. Wenner (ed.). Balkema, Rotterdam. 73-99.

COSTLOW, J. & BOOKHOUT, C.G. 1959. The larval development of *Callinectes sapidus* Rathbun reared in the laboratory. *Biological Bulletin 116*: 373-396.

DARNELL, R.M. 1959. Studies of the life history of the blue crab (*Callinectes sapidus* Rathbun) in Louisiana waters. *Transactions of the American Fisheries Society 88*: 294-304.

DAVIDSON, R.J. 1987. Natural food and predatory activity of the paddle crab, *Ovalipes catharus*: A flexible forager. Unpub. M.Sc. thesis. Zoology Department, University of Canterbury. 110pp.

DEVRIES, M.C., EPIFANIO, C.E & DITTEL, A.I. 1983. Reproductive periodicity of the tropical crab *Callinectes arcuatus* Ordway in Central America. *Estuarine, Coastal and Shelf Science 17*: 709-716.

GOTSHALL, D.W. 1978. Relative abundance studies of Dungeness crabs, *Cancer magister* in Northern California. *California Fish and Game 64*: 24-37.

HILL, B.J. 1974. Salinity and temperature tolerance of zoeae of the portunid crab *Scylla serrata*. *Marine Biology 25*: 21-24.

HILL, B.J. 1975. Abundance, breeding and growth of the crab *Scylla serrata* in two South African estuaries. *Marine Biology 32*: 119-126.

Hill, B.J., WILLIAMS, M.J. & DUTTON, P. 1982. Distribution of juvenile, subadult and adult *Scylla serrata* (Crustacea: Portunidae) on tidal flats in Australia. *Marine Biology 69*: 117-120.

HINES, A.H., LIPCIUS, R.N. & HADDON, A.M. 1987. Population dynamics and habitat partitioning by size, sex, and molt stage of blue crabs *Callinectes sapidus* in a subestuary of central Chesapeake Bay. *Marine Ecology Progress Series 36*: 55-64.

HOWARD, A.E. 1982. The distribution and behaviour of ovigerous edible crabs (*Cancer pagurus*), and consequent sampling bias. *Journal du Conseil Permanent International pour L'exploration de la Mer 40*: 259-261.

KLEIN BRETELER, W.C.M. 1976. Migration of the shore crab, *Carcinus maenas*, in the Dutch Wadden Sea. *Netherlands Journal of Sea Research 10*: 338-353.

KROUSE, J.S. 1976. Size composition and growth of young rock crab, *Cancer irroratus*, on a rocky beach in Maine. *Fishery Bulletin 74*: 949-954.

LIPCIUS, R.N. 1985. Size-dependent reproduction and molting in spiny lobsters and other long-lived decapods. In: Crustacean Issues 3: Factors in adult growth. A.M. Wenner (ed.). Balkema, Rotterdam. 129-148.

NORSE, E.A. & FOX-NORSE, V. 1977. Studies on portunid crabs from the Eastern Pacific. II. Significance of the unusual distribution of *Euphylax dovii*. *Marine Biology 40*: 374-376.

OSBORNE, T.A. 1987. Life history and population biology of the paddle crab *Ovalipes catharus*. Unpub. Ph.D. thesis. Zoology Department, University of Canterbury.

PARK, J.R. 1969. A preliminary study of portunid crabs in Biscayne Bay. *Quarterly Journal of the Florida Academy of Sciences 32*: 12-20.

PAUL, R.K.G. 1982. Abundance, breeding and growth of *Callinectes arcuatus* Ordway and *Callinectes toxotes* Ordway (Decapoda, Brachyura, Portunidae) in a lagoon system on the Mexican Pacific coast. *Estuarine, Coastal and Shelf Science 14*: 13-26.

PENN, J.W. 1977. Trawl caught fish and crustaceans from Cockburn Sound. *Report of the Department of Fisheries and Wildlife, Western Australia 20*: 1-24.

POTTER, I.C., CHRYSTAL, P.J. & LONERAGAN, N.R. 1983. The biology of the blue manna crab *Portunus pelagicus* in an Australian estuary. *Marine Biology 78*: 75-85.

SANDOZ, M & ROGERS, R. 1944. The effect of environmental factors on hatching, moulting and survival of zoea larvae of the blue crab, *Callinectes sapidus* Rathbun. *Ecology 25*: 216-228.

SASAKI, K & KAWASAKI, T. 1980. Some aspects of the reproductive biology of the swimming crab *Ovalipes punctatus* (De Haan), in Sendai Bay and its adjacent waters. *Tohoku Journal of Agricultural Research 30*: 183-194.

SLOAN, N.A. 1985. Life history characteristics of fjord-dwelling golden king crabs *Lithodes aequispina*. *Marine Ecology Progress Series 22*: 219-228.

SMITH, H. 1982. Blue crabs in South Australia - their status, potential and biology. *Safic* (Adelaide, Australia) *6*: 6-9.

STEAD, D. 1983. Paddle crab investigations. *Catch 10(2)*: 14-15.

WEAR, R.G. 1982. Paddle crabs: a potential industry or a pest? *Catch 9(11)*: 16-17.

WEAR, R.G. & FIELDER, D.R. 1985. The marine fauna of New Zealand: larvae of the Brachyura (Crustacea, Decapoda). *New Zealand Oceanographic Institute Memoirs 92*: 1-90.

WEAR, R.G & HADDON. M. 1987. Natural diet of the crab *Ovalipes catharus* (Crustacea, Portunidae) around central and northern New Zealand. *Marine Ecology Progress Series 35*: 39-49.