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Burrowing behaviour of the paddle crab *Ovalipes catharus* (White, 1843) (Brachyura: Portunidae)

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Abstract The burrowing behaviour of *Ovalipes catharus* (White, 1843) is described and compared with that of some other burrowing crabs. *O. catharus* is a fast, back burrowing crab which makes temporary burrows in soft sand. The average time from initiation of burrowing to complete submergence was 6.5 s, there was no difference between males and females but burrowing time increased significantly with crab size. Similar morphological adaptations are required for burrowing and swimming: streamlined body shape, smooth lightly constructed exoskeleton, and flattened legs. *O. catharus* has a reversed respiratory current like *O. guadulpenensis* but it differs in its burrowing behaviour. Compared to some other crabs, burrowing in *O. catharus* is rapid.

Keywords Portunidae; *Ovalipes catharus*; behaviour; back-burrowing; burrowing rate; paddle crab

INTRODUCTION

Paddle crabs, *Ovalipes catharus* (White, 1843), have been recorded in New Zealand from Northland to Stewart Island and at Chatham Island, occurring off surf beaches and in estuaries, mainly on sandy bottoms (Stead 1983). Early accounts of burrowing by this crab were given by Chilton (1910), Thomson (1912), and Chilton & Bennett (1929), although these are inadequate, conflicting, and somewhat erroneous. *O. catharus* is able to burrow rapidly. During the day most crabs remain buried in the sand (Stead 1983) emerging soon after sunset and searching for food which consists largely of bivalves (Wear 1984). Evidence from fish gut samples

(Wear 1982, 1984; Stead 1984) suggests that *O. catharus* is eaten by over 30 species of commercially taken fish including snapper (*Chrysophrys auratus*), groper (*Polyprion oxygeneiosis*), and rig (*Mustelus lenticulatus*). King and Clark (1984) found that only mature female rig captured in shallow water (< 10 m) ate *O. catharus*. Since it lives on open sandy bottoms the crab can swim for cover, 'stand and fight', or escape from an aggressor by burrowing. The larger crabs (> 70 mm carapace width) can afford the risk of confronting their enemies but small crabs must take evasive action. Hence burrowing is an important means of escape from predators. The pale brown coloration with dark brown markings on the carapace reduce the conspicuousness of *O. catharus* on a sandy bottom.

O. catharus is typical of portunids in that it is a rapidly moving predator with a lightly built exoskeleton, slim legs, and large eyes, compared to other crabs. The chelae are comparatively long and narrow and are used very aggressively towards other animals. Portunid crabs depend upon speed (*Calinectes sapidus* can swim at speeds of over 1.0 m s⁻¹ Spirito 1972) to avoid the attention of predators but when escape is impossible they will fight back by lunging upwards with both chelae. The streamlined shape of the body is adapted for both rapid swimming and burrowing.

The burrowing mechanisms of marine animals have been reviewed by Trueman and Ansell (1969) who point out that burrowing consists of a step-like series of movements into the substrate which comprise a digging cycle. This short study was undertaken to firstly describe the digging cycle or burrowing behaviour sequence and secondly to measure the time taken to burrow by *Ovalipes catharus*. The major variables were crab size and sex. Although the swimming behaviour of portunids has attracted some attention (Hartnoll 1971; Spirito 1972) their burrowing behaviour has not been closely studied. Caine (1974) has described the burrowing behaviour and morphological adaptations for burrowing of *Ovalipes guadulpenensis*.

METHODS

Crabs were collected from Kaikoura and Banks Peninsulas and transported to the Edward Percival Field Station. Each crab was measured with vernier calipers (carapace width (CW) ± 1 mm) and

sexed. The mean CW of males used in the experiment was 65.0 mm (standard deviation (s.d.) = 25.4) and for females 60.1 mm (s.d. = 19.2). None of the female crabs used were carrying eggs. Burrowing rates of smaller crabs were measured in a black plastic tank 600 × 450 × 110 mm (depth) containing 30 mm of fine beach sand. For larger crabs 70 mm of sand was used. Measurement of burrowing rates was carried out on individual crabs during daylight hours with overhead illumination at 15.3°C. The burrowing time was measured with a digital stop watch from the time that the paddle-shaped fourth walking legs were dug into the sand until the crab disappeared beneath the surface. Burrowing time for 13 males and 14 females was measured 3–5 times with 2–5 minutes between burrowing episodes. After the initial measurement the crabs were not handled again but were forced to emerge from their hiding place on to the surface and then allowed to re-burrow. Single burrowing episodes were measured for another 17 males and 11 females. In total 72 observations of males and 67 observations of females burrowing were made.

Data on burrowing rates were analysed using the analysis of variance and covariance with repeated measures program, BMDP2V, on a computer.

RESULTS

Burrowing behaviour

In describing the burrowing behaviour we will refer to the 5 pairs of pereopods of the crab as chelipeds (first pair of pereopods) and 4 walking legs where the paddle-shaped pereopods are the last pair of walking legs.

O. catharus begins to burrow by searching over the surface of the sand for a suitable site. It moves sideways on the sand pausing to push its first 2 pairs of walking legs into the sand. Crabs were seen to transfer small amounts of sediment to the maxillipeds using the flattened dactyls of the first pair of walking legs like spoons. Only one leg at a time was used to 'spoon up' the sediment. This behaviour may have been used to detect the possible presence of a burrowed *O. catharus* and to 'taste' the sediment. If the site was unsuitable, searching was continued elsewhere (see Fig. 1 behaviour flow chart). For small crabs (< 70 mm CW) this period of searching was short (0–5 s) but larger crabs spent more time in this exploratory phase.

Prior to burrowing, the chelae were usually extended and spread apart in an aggressive or defensive manner with fingers gaping. When the decision was made to burrow the first step taken by the crab was to push the paddle-shaped dactyls

of the last pair of walking legs into the sand while the dactyls of the remaining legs were inserted into the sand to stabilise the crab. The insertion of the fourth legs probably allows the crab to measure the depth of soft sand and to test for the presence of obstructions which would prevent burrowing. When there was insufficient sand beneath the crab the first 3 pairs of legs were used to loosen the sediment. Each dactyl was extended laterally and then inserted into the sand and pulled towards the crab. Leg-digging continued for several minutes when the bottom of the tank was encountered. The insertion of the fourth pair of legs was accompanied by a raising of the body until it was almost vertical. The first pair of walking legs was extended and if the chelae were not being displayed they also aided in the elevation of the body. If the site proved unsuitable (e.g., insufficient depth of sand) it was rejected at this stage and another period of searching begun.

If burrowing continued, the next step involved a sudden forward thrust of the body so that the sternum of the crab pushed the sand forwards and towards each side. This behaviour created a shallow depression into which the crab could settle. On a small number of occasions (c. 10%) the sternum-push was repeated but when this was necessary the crab usually (c. 90%) abandoned the burrowing sequence and began searching for a new site. Up until this point the whole carapace and chelae were still visible. The chelae were not involved in burrowing. If the chelae were not being displayed and were folded across the anterior margin of the carapace, they were sometimes used to enlarge the front of the depression.

The last stage of burrowing involved a backward movement into the sand. The walking legs, especially the paddle-shaped last pair, undoubtedly aid this movement but observation of their use was obscured by the sand. Pushing backward, especially by the first walking legs, drives the crab under the sand and also pushes sand forward and up in front of the animal. Therefore the crab performed the entire burrowing sequence with or without using its chelae. As the crab pushed horizontally backward the surface sediment behind the crab spilled forwards and sediment in front of the crab fell backwards over the carapace and chelae concealing the entire animal under 10–20 mm of sand. When the burrowing crab was displaying its chelae these were the last parts of the animal to disappear into the sand. After the carapace was covered the chelae were finally folded in against the frontal margin. Some crabs buried themselves entirely whereas others (especially larger crabs) left their eyestalks protruding from the sand. The resting position under the sand was always horizontal. Often the only visible evidence of the crab was the move-

ment of the sand created by the emergence of water near the bases of the last legs caused by the respiratory current, which is the reverse of non-burrowing crabs (see Caine 1974). Burrowed crabs in a glass-sided aquarium were not observed to move their legs.

During daylight hours *O. catharus* remained buried in the sand emerging only occasionally, using the chelipeds to display aggressively towards any other crabs encountered and then re-burrowing at a new location. The frequency of occurrence of this activity was not monitored. At night the crabs were active and there was a high level of aggression in crowded tanks (c. 30 crabs m⁻²). Turning on a light at night caused an immediate burrowing response.

Speed of burrowing

The time taken to burrow was measured from the point where the crab inserted its fourth walking legs into the sand until it was completely covered (see Fig. 2). The burrowing time varied from 1 s for a small male (CW 37 mm) to 24 s for a large female (CW 110.5 mm). Burrowing time varied considerably but large crabs took longer to burrow than small crabs. Burrowing time increased linearly with carapace width. The mean time to burrow for all crabs was 6.5 s (s.d. = 0.53). The mean time for males was 6.2 s (s.d. = 4.64) and for females 6.8 s (s.d. = 5.22). Analysis of variance on burrowing rates shows that there is no significant difference between the sexes but there is a significant difference between crabs of different sizes (see Table 1). The lack of a difference between males and females was as expected since there are no major differences in body shape which could affect burrowing. In addition there was no detectable difference between the burrowing behaviour of males and females.

DISCUSSION

Burrowing crabs are back burrowers or side burrowers (Warner 1977). Back burrowers usually occupy temporary burrows underwater on sandy bottoms. These crabs include the highly specialised, anomuran mole crabs (*Emerita* spp.) which live in the surf zone of tropical beaches, and need to burrow rapidly to counteract the scouring action of breaking waves. They have elongated bodies, very reduced limbs, and exhibit tidal migrations (Efford 1965) which require the ability to burrow quickly and repeatedly. Other fast back burrowers have a much broader carapace and flattened legs which are also used for swimming, e.g., the European portunid, *Portumnus latipes*, and the Indo-Pacific calappid, *Matuta* spp. *Ovalipes catharus* is

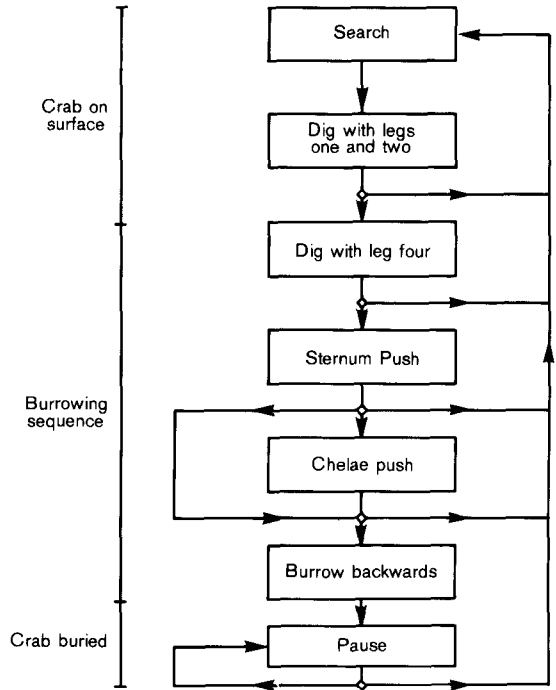


Fig. 1 A behavioural flow chart of burrowing by *Ovalipes catharus*. The flow chart is divided into 3 major sections: searching on the sand surface, burrowing, and buried.

typical of this kind of burrower having a smooth, thin, dorso-ventrally compressed carapace which is broader than long, flattened legs, and modified paddle-shaped dactyls on the last pair of legs. It has been suggested that the ancestors of swimming crabs were back burrowers and that swimming paddles may have evolved from flattened digging legs (Warner 1977). The thinner integument of swimming crabs (Spirito 1972) makes them lighter but surrenders a degree of protection from physical attack. Swimming may have evolved as a means of escape from predators but also probably facilitates foraging over a wider area.

The rapid burrowing by *Ovalipes catharus* (1–4 s for small crabs) is comparable to burrowing rates of tropical and temperate intertidal molluscs. Ansell and Trevallion (1970) reported rates of 1–6 s for the bivalves *Macra olorina* and *Donax* spp. and the gastropod *Bullia melanoides*.

Caine (1974) has described the burrowing of *Ovalipes guadulpens* into relatively firm substrates. This crab uses its walking legs to initially loosen up the sediment prior to burrowing. The angle of penetration of the body was about 60° and

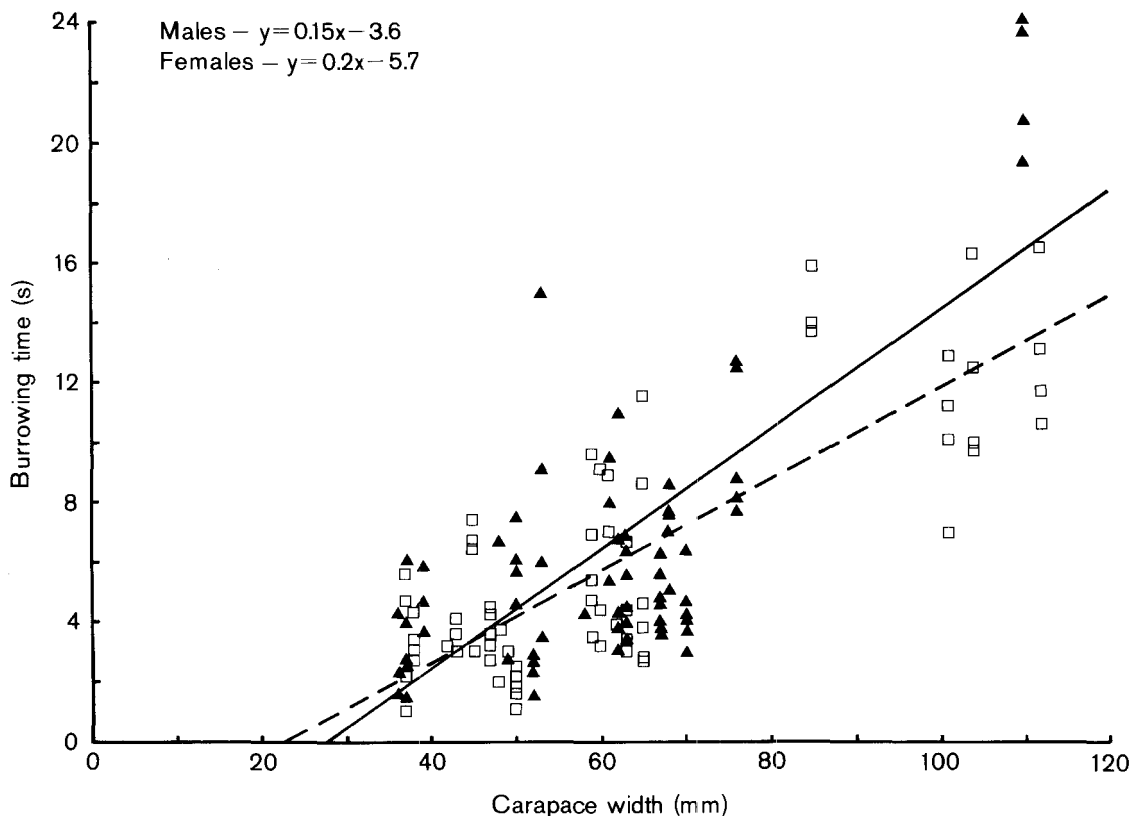


Fig. 2 The relationship between burrowing time (s) and carapace width (mm) for *Ovalipes catharus*. Males, \square ; females, \blacktriangle . The equations of the regression lines are for males (dashed line): $y = -3.57 + 0.152x$, $r = 0.78$, and for females (solid line): $y = -5.74 + 0.199x$, $r = 0.73$.

the walking legs were used to pull the crab down into the sediment while the chelipeds were folded tightly against the carapace. Once the legs were extended into the sediment the body was raised and the chelipeds used to scoop and push sand forward from underneath. Next a 'body slam' was used to force waterborne sand upwards which subsequently settled on top of the crab. The 'body slam' forced the crab deeper into the sand and was repeated until the carapace was completely covered. The main difference between *O. guadulpens* and *O. catharus* is in the use of the 'body slam'. *O. catharus* uses a 'sternal push' (usually only once) to push sediment aside and when burrowing is complete the crab is behind the initial point of entry. Conversely *O. guadulpens* ends up buried at the same spot where it started burrowing. The time taken to burrow by this crab was not recorded by Caine (1974). The burrowing of *Atelecyclus rotundatus* was briefly described by Taylor (1984). This crab uses the combined action of the legs and

chelae to drive the body back into the sand at a moderately steep angle in a manner similar to *O. catharus*.

The burrowing behaviour of the leucosid *Ebalia tuberosa* has been studied by Schembri (1981). This crab prefers coarse sediment for burrowing and unlike *Ovalipes catharus*, which burrows in a few seconds, it may take from 130–1000 s to burrow completely. The initial stages of burrowing by *Ebalia tuberosa* are similar to *Ovalipes catharus*: preliminary exploration of the substrate, occasional probing with the dactyls of the walking legs, burrowing commencing with the body tilted upwards and the last 2 pairs of legs pushed into the sediment. The remainder of the burrowing sequence in *Ebalia tuberosa* differs in that three different techniques may be used to cover the carapace, with the chelipeds being used to move sediment backwards. There were no significant differences between males and females, and like *Ovalipes catharus* there was a significant positive relationship between burrow-

Table 1 Analysis of variance of burrowing rates of *Ovalipes catharus*.

Source	SS	df	MS	F
Sex	10.94	1	10.94	0.4 $P = 0.53$
Size	1546.78	1	1546.78	56.63 $P < 0.0001$
Error	682.82	25	27.31	

ing time and crab size. The longer duration of burrowing in *Ebalia tuberosa* is associated with the cryptic shape and coloration of the crab and rapid concealment is probably not as essential. Melrose (1975) described burrowing of the hymenosomatid *Halicarcinus whitei* in fine sand. Burrowing is a much more gradual process than in *Ovalipes catharus*. It begins with pushing the carapace backwards into the sand aided by the legs and chelae which gradually settle beneath the surface. The rostral area and folded chelae may remain on the surface. Burrowing in both *Ebalia tuberosa* and *Halicarcinus whitei* is much slower than in *Ovalipes catharus*.

Back-burrowers are probably a more diverse group than indicated by Warner (1977); more recent work suggests that their rates of burying and burrowing behaviour differ. Some push the body back and downward at an angle whereas others excavate a place to burrow using a 'body-slam' method. Some use chelipeds to heap sand over the body and others do not. The result is that some of these crabs (e.g., *Ebalia*, *Ovalipes guadulpensis*) enter the sand directly whereas others (e.g., *O. catharus*, *Atelecyclus*) slide backwards into the sand. The latter method is probably more rapid and deceptive for a pursuing predator.

The behaviour used by *Ovalipes catharus* to excavate bivalve prey from the sand has been briefly described by Wear (1984). The crab balances on its third pair of walking legs using the paddle-shaped last pair as a stabiliser and then rocks forward to 'bulldoze' the bivalve out with the first and second pairs of walking legs. This behaviour is similar to the initial phase of burrowing when the walking legs are used to loosen the sand but instead of being pushed forwards to expose the prey, the legs are extended and pulled towards the crab thereby facilitating penetration. This similarity is not surprising since both behaviours are directed at the substrate, although the objective is different.

A major problem for burrowing crabs is the maintenance of a respiratory current. In non-burrowing crabs the currents pass upwards between the walking legs or through the Milne Edwards openings dorsal to the basis of the chelipeds and into the branchial chambers. The scaphognathite

pulls water through the branchial chamber and out through the buccal area. Occasional short reversed currents occur in these crabs (Borradaile 1922). Caine (1974) found that in both buried and unburied *Ovalipes guadulpensis* a reversed water current was used. Most water entered the buccal area to the scaphognathite, passed through the branchial chamber, and then was exhaled antero-lateral to the last walking legs. Water was pushed rather than pulled through the branchial chamber. Dense setae around the antennae, first and third maxillipeds, and the bases of the walking legs and chelipeds prevented entry of sand particles. The Milne Edwards openings are reduced and they can be closed. While buried, occasional reversion to the normal pattern of respiratory flow occurred; water was exhaled from the buccal cavity which aided in gill cleaning and the clearing of sand and detritus from the filtering setae. Our observations suggest that *O. catharus* has the same pattern of respiration. Immediately after burrowing, water was seen bubbling up through the sand at the posterior end usually ceasing within a few seconds, but in large crabs continuing for several minutes, indicating that the respiratory current is much reduced.

In their revision of the genus *Ovalipes*, Stephenson and Rees (1968) separated the 10 species into two groups (A and B) and four sub-groups. *O. catharus* belongs in the '*O. punctatus*' sub-group (group A) and *O. guadulpensis* belongs in the '*O. ocellatus*' sub-group (group B). Our comparison of the burrowing behaviours of *O. catharus* and *O. guadulpensis* has shown several major differences which support this sub-division. However, too little is known about the burrowing of other *Ovalipes* species to say whether these two species are typical of their respective groups. It would be valuable for future workers to make a comparison between *O. catharus* and *O. molleri* which has been recorded from northern New Zealand (see Dawson & Yaldwyn 1974) since *O. molleri* belongs to the '*O. irridescens*' sub-group (group B). This would also make it possible to compare *O. molleri* and *O. guadulpensis* which both belong to group B to see whether they have similar burrowing behaviour.

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REFERENCES

- Ansell, A. D.; Trevallion, A. 1970: Behavioural adaptations of intertidal molluscs from a tropical sandy beach. *Journal of experimental marine biology and ecology* 4: 9–35.

- Borradaile, L. A. 1922: The mouthparts of the shore crab. *Journal of the Linnean Society (zoology) London* 35: 115-142.
- Caine, E. A. 1974: Feeding of *Ovalipes gadulpensis* (Saussure) (Decapoda: Brachyura: Portunidae), and morphological adaptations to a burrowing existence. *Biological bulletin Woods Hole* 147: 550-559.
- Chilton, C. 1910: The Crustacea of the Kermadec Islands. *Transactions New Zealand Institute* 43: 544-573.
- Chilton, C.; Bennett, E. W. 1929: Contributions for a review of the Crustacea Brachyura of New Zealand. *Transactions and proceedings New Zealand Institute* 59: 731-778.
- Dawson, E. W.; Yaldwyn, J. C. 1974: *Ovalipes molleri* (Ward), a portunid swimming crab new to New Zealand: occurrence and distinguishing features. *New Zealand Oceanographic Institute records* 2(4): 45-48.
- Efford, I. E. 1965: Aggregation in the sand crab, *Emerita analoga* (Stimpson). *Journal of animal ecology* 34: 63-75.
- Hartnoll, R. G. 1971: The occurrence, methods and significance of swimming in the Brachyura. *Animal behaviour* 19: 34-50.
- King, K. J.; Clark, M. R. 1984: The food of rig (*Mustelus lenticulatus*) and the relationship of feeding to reproduction and condition in Golden Bay. *New Zealand journal of marine and freshwater research* 18: 29-42.
- Melrose, M. J. 1975: The marine fauna of New Zealand: Family Hymenosomatidae (Crustacea, Decapoda, Brachyura). *New Zealand Oceanographic Institute memoir* 34: 123 p.
- Schembri, P. J. 1981: Substratum preferences, burrowing and righting in *Ebalia tuberosa* (Pennant) (Decapoda: Leucosiidae). *Marine behaviour and physiology* 8: 149-161.
- Spirito, C. P. 1972: An analysis of swimming behaviour in the portunid crab *Callinectes sapidus*. *Marine behaviour and physiology* 1: 261-276.
- Stead, D. 1983: Paddle crab investigations. *Catch* 10(2): 14-15.
- 1984: Crab fishery expansion possible. *Catch* 11(5): 13-14.
- Stephenson, W.; Rees, M. 1968: A revision of the genus *Ovalipes* Rathbun, 1898 (Crustacea, Decapods, Portunidae). *Records of the Australian Museum* 27: 213-261.
- Taylor, A. C. 1984: Branchial ventilation in the burrowing crab, *Atelecyclus rotundatus*. *Journal Marine Biological Association, UK* 64: 7-20.
- Thomson, G. M. 1912: The natural history of Otago Harbour and the adjacent sea, together with a record of the researches carried on at the Portobello Marine Fish-hatchery. *Transactions and proceedings New Zealand Institute* 45: 225-251.
- Trueman, E. R.; Ansell, A. D. 1969: The mechanisms of burrowing into soft substrata by marine animals. *Oceanography and marine biology annual review* 7: 315-366.
- Warner, G. F. 1977: The biology of crabs. London, Elek Science. 202 p.
- Wear, R. G. 1982: Paddle crabs: a potential industry or a pest? *Catch* 9(11): 16-17.
- 1984: Paddle crabs are probable predators. *Catch* 11(5): 11-13.