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Evaluation of the catch mechanism of conventional conical snow crab (*Chionoecetes opilio*) traps by underwater video camera observations

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by

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ABSTRACT

The catch mechanism of a conical snow crab (Chionoecetes opilio) trap was observed by means of underwater video camera in Baie des Chaleurs. This study suggested that the bait substance that attracts the snow crab may not be diffused 360 degrees around a trap. The attractive or effective area fished may form a strip which could be schematized by a lemniscate shape for a 12 h tidal cycle. The location of the bait and the number of entrances seem to be important factors governing the performance of the trap. The most efficient trap of those tested in the study was the conventional conical single large entrance trap which was baited in the center, at lower than middle height.

RÉSUMÉ

Des observations sur le mécanisme de capture d'un casier conique de crabe des neiges (Chionoecetes opilio) ont été effectuées, avec une camera vidéo sous-marine dans la baie des Chaleurs. Les observations ont suggéré que l'aire d'attraction de ce type de casier n'était pas 360 degrés. L'aire d'attraction ou la superficie efficace de pêche du casier conique semble être en forme de bande qui peut se schématiser en forme ellipsoidale pour un cycle d'une marée de 12 h. La position de l'appât et le nombre d'entrée d'un casier conique sont des facteurs importants pour la performance de ce casier. Le casier conique le plus efficace, d'après notre étude est celui avec une grande entrée dont l'appât est positionné au centre, à une hauteur moindre que la hauteur médiane.

INTRODUCTION

Comments made by snow crab (Chionoecetes opilio) fishermen, based on their fishing experience, that some traps caught a considerable quantity of crabs while others did not, despite identical features of trap design, quantity of bait, depth and fishing locations, prompted this study. In addition, many fishermen have recently changed their trap type from square to large conical (Chiasson et al. 1992). These conical traps, according to the local snow crab fishermen, are more efficient, easier to manipulate and stackable for transport.

To better understand the fishing mechanism of conventional traps, a series of surveys were conducted by Moriyasu et al. (1989) that showed that conical traps catch more and larger crabs. However, they did not determine the reason for the considerable variation in the fishing performance by an identical trap type or the higher catch performance of the conical traps compared to square traps. The present study evaluates, by direct observations using an underwater video camera system, the relationship between catch performance of standard conical snow crab traps and various factors, such as bottom current, bait position and gear design.

MATERIALS AND METHODS

Underwater Video Camera Equipment:

A metal frame was constructed to support the main video camera system, the lights and the pan and tilt mechanism above the conical traps to observe crab behaviour (Fig. 1). This set up was controlled electronically via an armoured cable (12 conductors + 1 coax) and an oceanographic winch. The system was controlled (light intensity, camera focus and position) from inside the accompanying fishing vessel (CFV PRAGA - 20 meters). The system used 110 volt AC power provided by the vessel generator and was stabilized by a current transformer. A red filter was attached to the lights as luminance intensity affects crab behaviour (Conan et al. 1984). In 1991, light intensity was controlled by observation to reduce the negative effects on crab behaviour, while maintaining a minimum acceptable image. In 1992, a more sensitive camera was used which required less illumination. The observations were made using a black and white monitor and recorded on a VHS video recorder. The technical characteristics of each component of the underwater video camera system used in 1991 and 1992 surveys are summarized in Table 1.

For the 1991 underwater video survey, a small pipe inspection camera (DeepSea Power & Light Co. CCD-DVC 500L) was adapted to the set up. It's minimum illumination of 4 lux at F1.6 required two remote intensity controlled red filtered lights. The intensity of the lights was controlled manually to obtain a clear image without disturbing crab behaviour. For the 1992 survey, a SIT (Silicon Intensifier Target Osprey OE1323) camera was obtained for the set up. It's minimum illumination is 0.0001 Lux at faceplate. Only one remote red filtered light was used. The maximum light intensity needed did not have any visible effect on the crab behaviour. The field-of-view was much improved with the Osprey camera providing 100 degree diagonal, 98 degree horizontal and 81 degree vertical capacity compared to the pipe camera providing only 47 degree diagonal. This new equipment monitored a larger area of the trap in one field-of-view than in the 1991 survey.

The vessel was stabilized with two anchors to compensate for current and wind changes, monitoring at depths ranging from 80 to 90 m. Monitoring time with periodic reseting of the trap on the sea bottom varied from 2 to 14 h, up to 6 h of continuous observation without perturbing the bottom fine sediments was accomplished with favourable weather.

A new trap orientation device, i.e. a metal fin attached to the back of the video camera, used in the 1992 survey automatically aligned the camera field-of-view to face into the current, when the system was deployed on the sea bottom. This orientation device was helpful when monitoring the side of the trap and observing the crab movement on the same side of the underwater camera.

The quality of the images recorded in the 1992 survey were superior to those obtained in the 1991 survey. This was due not only to the performance of the SIT camera but also the experience gained from the 1991 survey pertaining to the positioning of the lights and the location of the camera and pan/tilt equipment.

Trapping experiment and underwater video observation:

The experiment was conducted from June 26 to July 15, and from July 28 to August 20, in 1991 and 1992 respectively, in Baie des Chaleurs (Fig. 2) at the depths ranging from 80 to 90 m. The detailed schedule of underwater video observations is summarized in Table 2. Conventional large conical snow crab traps (180 cm in bottom diameter x 55 cm in height) with different numbers of entrances (one, two and four) were used for the experiment (Fig. 3). An elevated conical trap originally constructed for a selectivity study (Fig. 6) was also observed to better understand and visualize the catch mechanism of a conventional conical snow trap. This trap was elevated 45 cm from the ground resulting in the bait being approximaty 70 cm off the bottom.

For each experiment, approximately 2 kg of fresh Atlantic mackerel (Scomber scombrus) was place in a mesh bag attached in the center or to the inside edge at middle height of the trap (Fig. 3). For conical traps with two or four entrances, the bait was hung from the top center of the trap frame. In the case of the single entrance, the bait was hung from a string attached to both sides across the center of the trap.

To examine one effect of the current on the fishing ability of the conical trap and to quatify the movement and number of crabs, the camera was mounted for a top view one meter over a single entrace conical trap that was baited in the centre. The field-of-view included all sides of the trap. The single entrance area was divided into four zones for image analysis of crab movements. To assess the bottom current intensity and direction, small threads were attached to the metal frame (Fig. 4).

Experimental commercial fishing

In 1991, 150 traditional conical snow crab traps composed of 90 traps with two entrances and 60 traps with four entrances were used for commercial fishing. Based on preliminary observations of the catch performance of different trap types conducted in 1991 season, the CFV PRAGA used 150 conical traps with a single large entrance for commercial fishing purposes in 1992. The catch per trap haul was recorded and used to evaluate the fishing performance of the latter type of trap in the commercial fishery compared to 2 and 4 entrance traps used in 1991. The estimation of total catches for each trap type was based on logbook records and recorded observations (A. Paulin).

RESULTS AND DISCUSSION

Current direction and speed

Although, an accurate current speed was not measured during this study, relative current speeds were divided into three categories based on the string attached to the metal frame of the camera mount: negligible current (no movement of string), slow current (some movement of string) and rapid current (string approximately at right angles to the frame) (Fig. 4).

Under conditions of negligible current, no crabs were observed around the trap. At weak currents, a relatively low number of crabs (average one crab every 5 minutes) were observed. In general, as the current speed increases, the average number of crabs heading to the trap from the downstream direction increases (Average two crabs per 5 minutes at rapid current). In all observed cases, the crabs approched the baited trap from the downstream side (opposite direction) of the current. This area in which crabs were oriented towards the trap, for the purposes of this study is called the "attraction strip" (Fig. 5).

To quantify the movement and the number of crabs versus current direction, we monitored the large single entrance from a top fiew, for image analysis this large entrance was divided into four equal zones (Fig. 6). Subsequently the analysis of VCR images revealed that 95% of crab entered through zone 3, the opposite position from the current direction. No crabs entered through zone 1. Although some crabs entered zone 2 and 4, they approached the trap through zone 3 (Figs 6a and 6b). Although, there is no doubt that the current is the most important factor for the attraction of crab (Miller 1978; Caddy 1979; Brêthes et al. 1985), the identification of the actual attractive mechanism remains unknown. From these observations, it appears that current direction and strength plays a significant role.

The elevated bait (70 cm) from the modified elevated trap revealed yet another effect of the current speed and direction on snow crab movement. When the current was weak, crabs approached the trap and concentrated under or close to the trap (Fig. 7). As the current intensity increased, the crabs moved away from the trap (Fig. 7). This phenomenon can be identified as an "attraction tunnel". These observations suggest that the crabs are attracted by a substance from the bait which is carried away from the trap by the current. Theoretically, the base of the attraction strip, should reach or should be close enough to the bottom, that the substance emited from the bait will effectively attract the crab to the trap. Observations from this study suggest that positioning bait high in the trap (above 35 cm from the trap bottom) may reduce considerably its overall efficiency.

Miller (1979) reported that traps using exposed bait caught greater numbers of crab than traps with bait enclosed in perforated containers. The exposed baits give stronger odour than enclosed ones, which results in a greater catches. For the purpose of this study, the substance from the bait which attracts the snow crab will be call the odour. Our observations support the hypothesis that snow crabs are attracted by the bait odour transported by the current, as the catch performance is enhanced with strong bait odour and that the attractive area is increased with increasing current. In the southwestern Gulf of St. Lawrence snow crab fishery, the fishermen put the bait in a mesh bag or attach it unenclosed. According to the fishermen, the bait lasts longer using the former method because of lower predation by "sea fleas" (Amphipods). It is unknow if there is a differential catch performance between hung bait and that enclosed in a mesh bag.

The results of the present study have shown that the area of attraction of a trap, which is sometimes referred to as the "effective area" (Miller 1975), "effective fished area" (Brêthes et al. 1985) or "capturing field" (Eggers et al. 1982) is not a circular field of a fixed radius, but appears to be a lemniscate shape (twin avoid sectors positioned opposite of each other) over one complete tidal cycle (Fig. 9).

Bait position and number of entrances

The trapping ability of three types of conical traps (one large entrance, two and four small entrances) with varying bait position were evaluated. The two bait positions used were in the center of trap and closer to the side of the trap, both at mid height (Fig. 3). When the bait is positioned to the side so that the current would distrubute the "attraction tunnel" inside the trap, this would not have a negative effect on the catch. The crabs proceed to the bait, first by climbing up the trap slope (opposite side of the bait) and second by entering the entrance to approach the bait (Fig. 8a). Conversely, when the bait is positioned to the side so that the current distributes the "attraction tunnel" outside the trap slope, the number of crabs entering the trap is greatly reduced. In this combination of bait positioning and current direction, the crab climbs midway up the slope of the trap, where the odour is more concentrated (Fig. 8b). Crabs stayed on the slope until the trap was lifted or were bumped off by other crabs.

When the bait was placed in the centre of the trap, the "attraction tunnel" was not observed and the catch became consistently high, however crabs were often observed getting the bait without being captured by staying in between the entrances in the case of two and four entrances. No such observations were made from the single entrance traps, which do not allow crabs to reach the bait without entering the trap.

Experimental commercial fishing

Although not statistically valid, it is interesting to compare the fishing performance of the different traps used by the fishing vessel CFV/PRAGA. Comparison of the 1991 (150 conical traps composed of 90 traps with two entrances and 60 traps with four entrances) and the 1992 fishing seasons (150 traps with only one large entrance) revealed that the 1992 season al CPUE was 1.27 times (CPUE 1991 = 24.35/CPUE 1992 = 30.99) more efficient than 1991.

Miller (1978) reported that the ease of finding the entrance was an important variable determining the effectiveness of baited crab traps. Traps should therefore be designed so that the bait odour leads the crab to the trap entrance, not just to the trap. Miller (1978) also pointed out that escapement of the crabs from the trap due to agonistic encounters outside or inside the trap is also an important factor to consider when evaluating the catch performance. No legal size crabs were seen to escape from any of the conical traps used in this study.

Theoretically, when several traps are set in a row parallel to the current direction the trap located at the downstream end should catch the maximum of crab. If the current direction reverses, the trap at the other end of row should catch more. In any case, the traps located in the middle of the row should show a lower catch performance. If the current direction is perpendicular to the line of traps, then each trap should have a comparable catch performance.

Although increasing the trap catch performances may cause other problems within the fishery, it is also of benefit to the fishery (Area 12) to increase the efficiency in catch performance. Since this fishery is controlled by setting a conservative quota level and by the protection of newly molted crabs, an improved trap catch performance will reduce the total fishing effort and duration of fishing season and allow fishermen to obtain their quota before the incidence of molting white crab in the catch increases and closes the fishery.

CONCLUSION

The substance of the bait that attracts snow crab does not appear to be diffused 360 degrees around the trap, but forms an attraction strip which is a lemniscate shape for a 12 h tidal cycle (Fig. 9). Even with an immersion (soak) time which does not exceed 3 days in the southwestern Gulf of St. Lawrance and considerable changes in the current direction, the hypothesis of a circular surface of attraction for a trap is overestimated. The location of the bait and the number of entrances seem to be important factors which affect catch performance. The most efficient trap appears to be the single entrance conical trap in which the bait is positioned in the center of the trap at lower than middle height.

ACKNOWLEDGEMENTS

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N.B. This report was prepared as a collaborative venture between the Department of Fisheries and Oceans (DFO) and a commercial fisherman (the second author).

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Table 1. Technical characteristics of video system components used in the 1991 and 1992 sampling seasons.

Components	Descriptions
Main Camera 1991	Miniature black and white solid state CCD-DVC 500L pipe inspection camera, wide angle auto iris lens. Minimum illumination of 4 Lux at F1.6.
Main Camera 1992	SIT - Silicon Intensifier Target Osprey OE1323 .0001 Lux at face plate
Auxillary Camera	CM-8 black and white tube type 8844, remote focus - Sub Sea System.
Main light	Ultralight 500 watts, Remote Ocean Systems, intensity controlled at surface, with red filter
Second light for 1991	MK-X1 75 watts Sub Sea Systyem, intensity controlled at surface, with red filter
Pan and tilt	PT-10, Remote Ocean Systems
Oceanographic winch	12 conductors, 1 coax cable

1991 - 2 light system - Ultralight control setting at approx. 75 volts AC +/- 15 volts AC (300 watts)
MK-X1 control setteing at approx. 20 volts DC +/- 5 volts DC (50 wattes)
1992 - 1 light system - Ultralight control setting at approx. 25 volts AC +/- 5 volts AC (100 watts)

Table 2. Summary of trap observations made in the Baie des Chaleurs area in 1991 and 1992 by using underwater video camera systems.

Dates	Position latitude/longitude	Duration	Study - Main purpose	Number of crabs	Comments
26-Jun-91	15082.80/30903.15	18h00-05h30	Selectivity*	48	Modified conical 3LA
27-Jun-91	15094/30982	16h00-18h00	Selectivity	not recorded	Square
03-Jul-91	15093.20/30974.30	18h00-04h15	Selectivity	127	Modified conical 2LA
04-Jul-91	15093/30975	16h00-06h00	Selectivity	41	Modified conical 1LA-1LA
05-Jul-91	15093/30975	17h00-24h00	Selectivity	32	Modified conical 1LA
07-Jul-91	15082.28/30833.05	20h00-22h00	Selectivity + Current effect	46	Elevated trap 3L
11-Jul-91	15080/30826	(4 hours)	Selectivity + Current effect	26	Elevated trap 2L
12-Jul-91	15085.11/30859.16	19h00-24h00	Selectivity + Current effect	63	Elevated trap 1L
13-Jul-91	15077.38/30778.01	11h30-14h00	Selectivity + Current effect	27	Elevated trap 1/2L
14-Jul-91	15077/30778	(2 hours)	Current effect**	23	Conical 2 entraces
15-Jul-91	15077.43/30779.53	16h00-18h00	Current effect	36	Conical 1 entrace
23-Jul-91	15077.02/30762.97	13h30-17h00	Current effect	added below	Conical 4 entraces. High winds
24-Jul-91	15076.00/30757.00	(3.5 hours)	Current effect	56	Conical 4 entraces, bait middle and side
25-Jul-91	15075.80/30745.10	(2.5 hours)	Current effect	40	Conical 2 entraces, bait middle and side
26-Jul-91	15076.54/30765.33	(4 hours)	Current effect	67	Conical 1 entrace, bait middle
28-Jul-92	15090/30832	(2 hours)	Selectivity	not recorded	Modified conical 1/2LV
29-Jul-92	15090/30832	(2 hours)	Selectivity	16	Modified conical 1LV
18-Aug-92	15082/30903	18h00-00h40	Selectivity	19	Modified conical 2LV
19-Aug-92	15093/30975	18h00-02h00	Selectivity	22	Modified conical 3LV
20-Aug-92	15086/30844	(3 hours)	Current effect	79	Bird's eye view, conical 1 entrance

* Studies on the catchability of modified trap to minimized the capture of white, undersized and female crabs (Technical report in preparation).

** This study

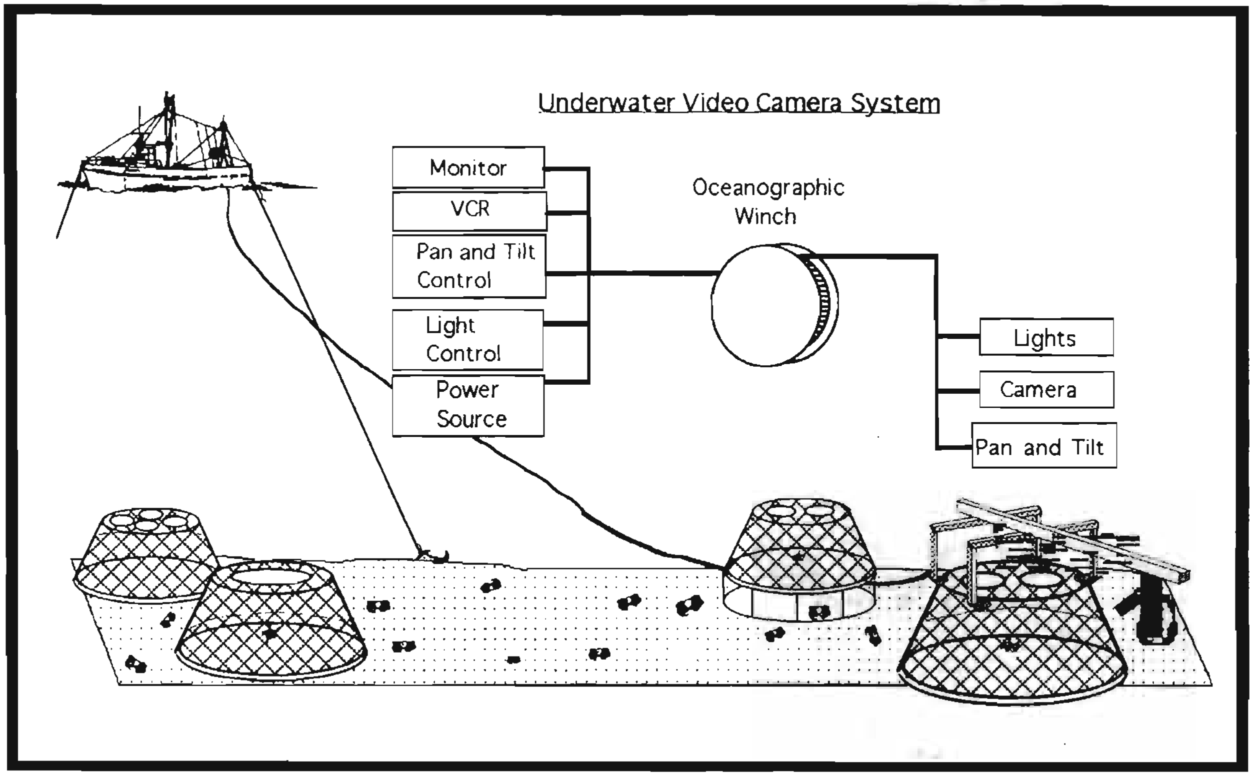


Figure 1. Diagram of the underwater video camera system set up.

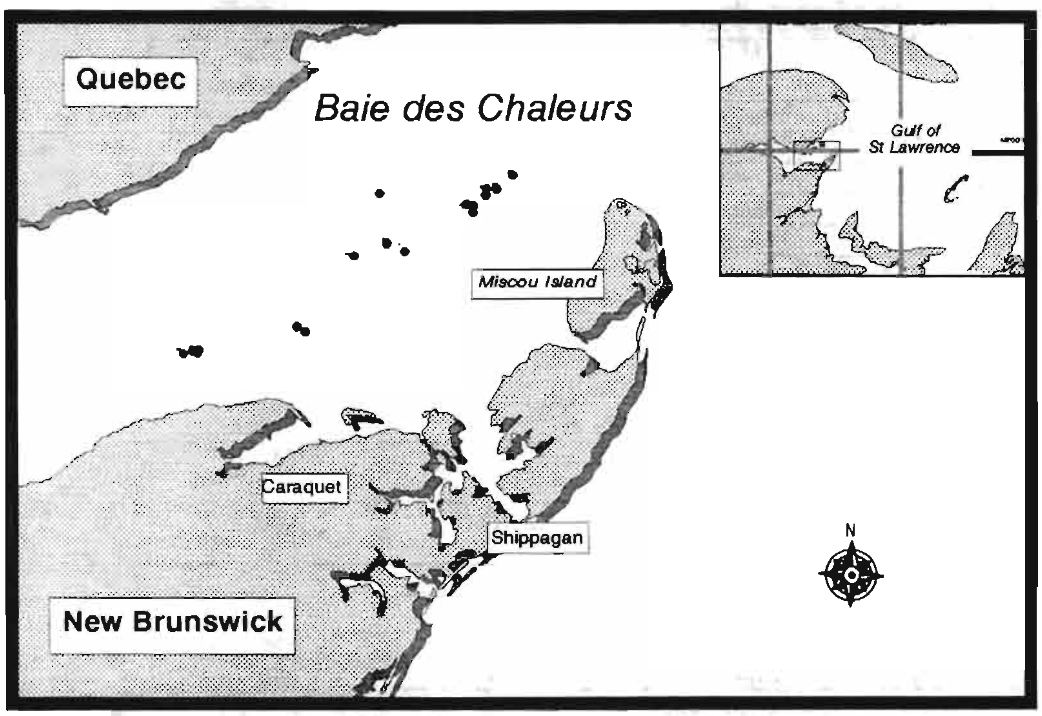


Figure 2. Geographic location of study sites (•) in Baie des Chaleurs, New Brunswick.

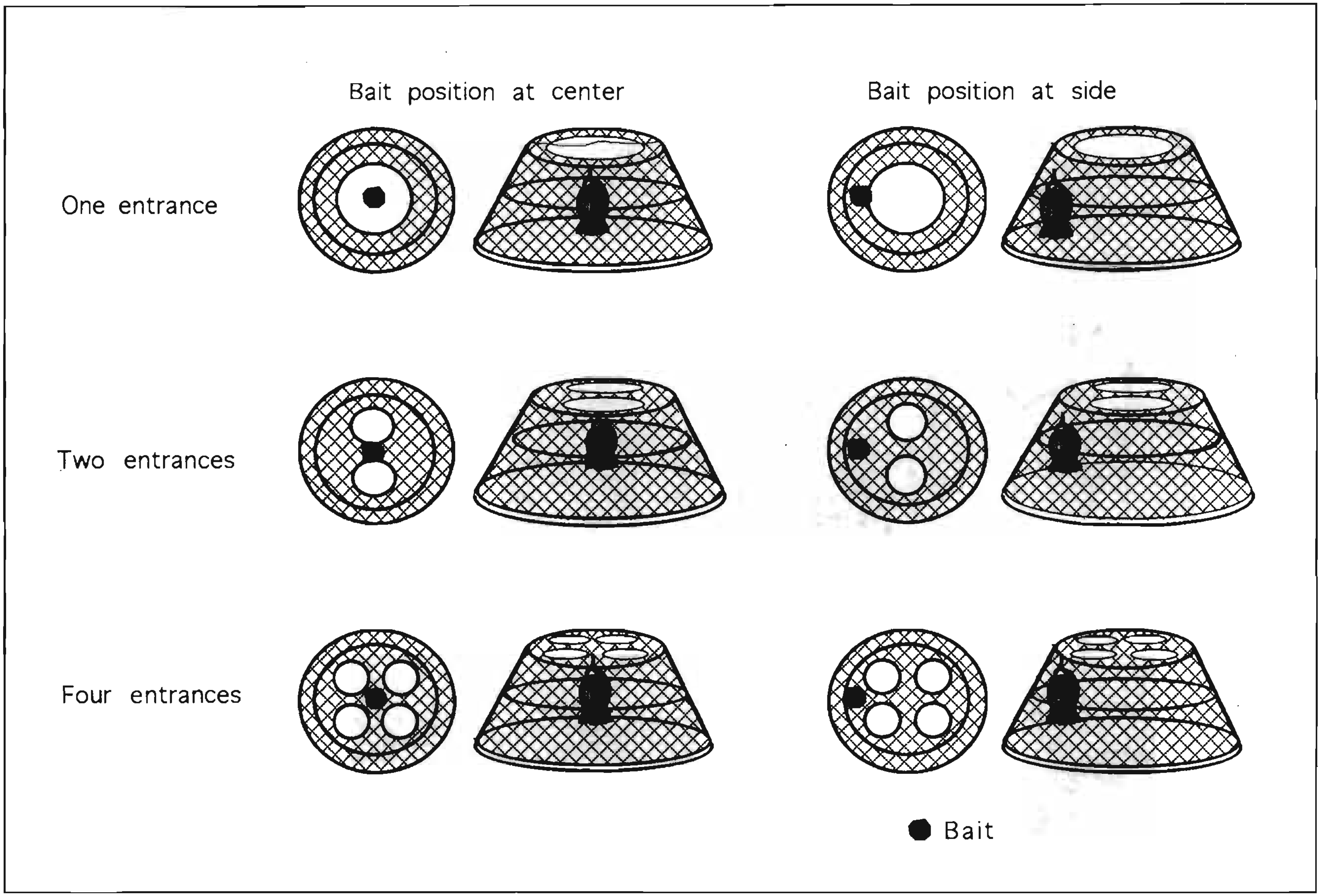


Figure 3. Positions of bait in different types of conical snow crab (Chionoecetes opilio) traps.

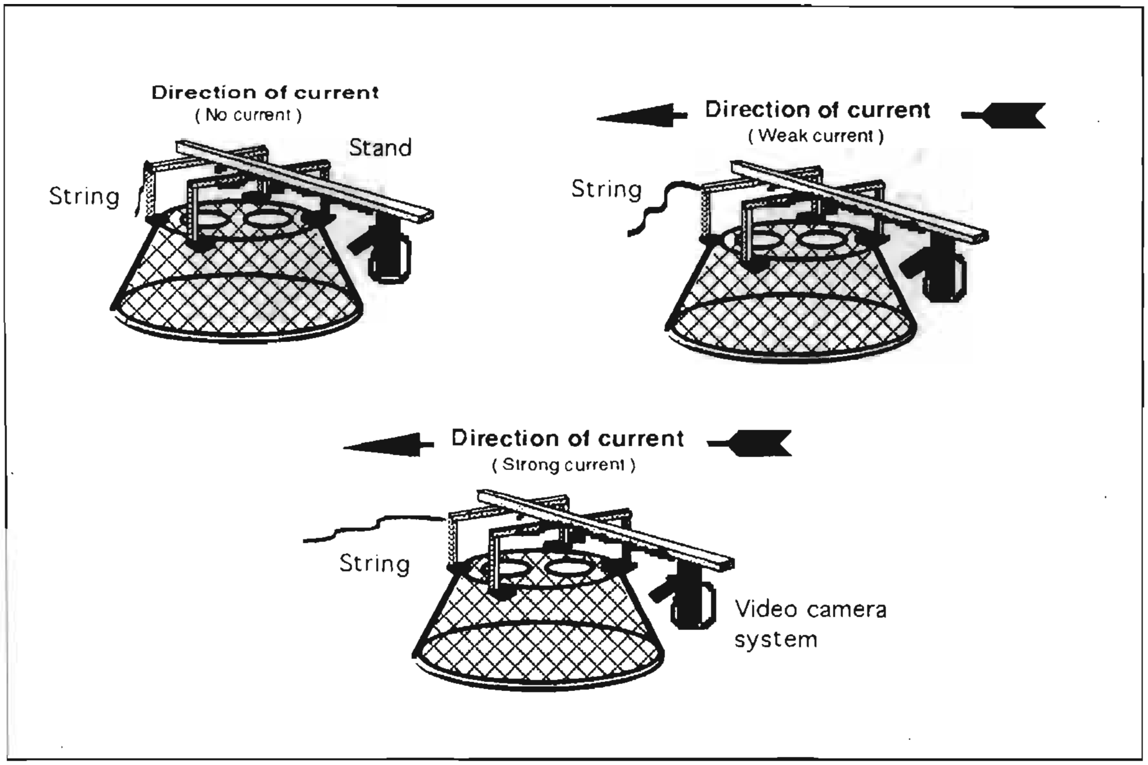


Figure 4. Assessing current intensities and vectors in relation to the conical snow crab (Chionoecetes opilio) trap.

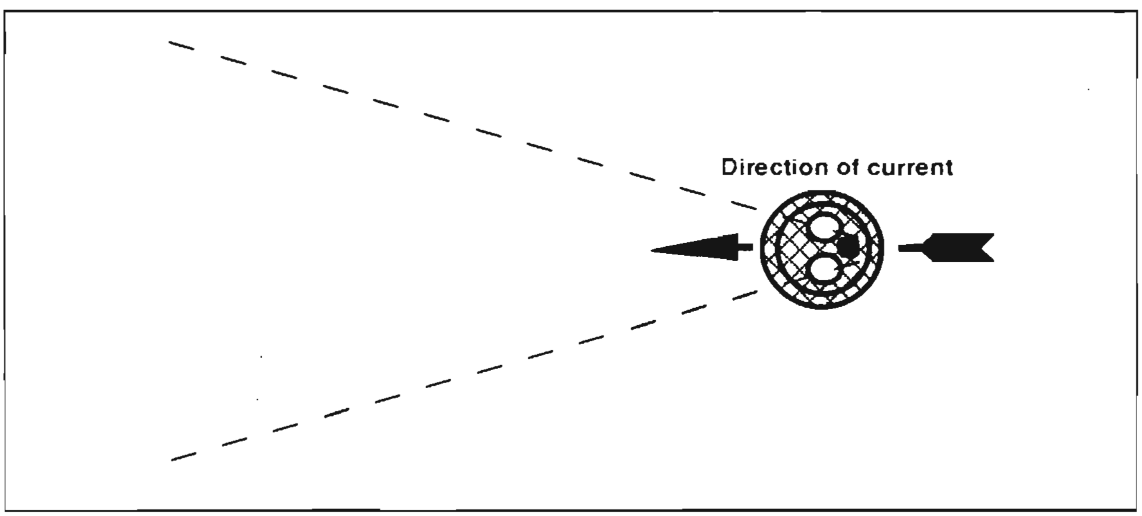
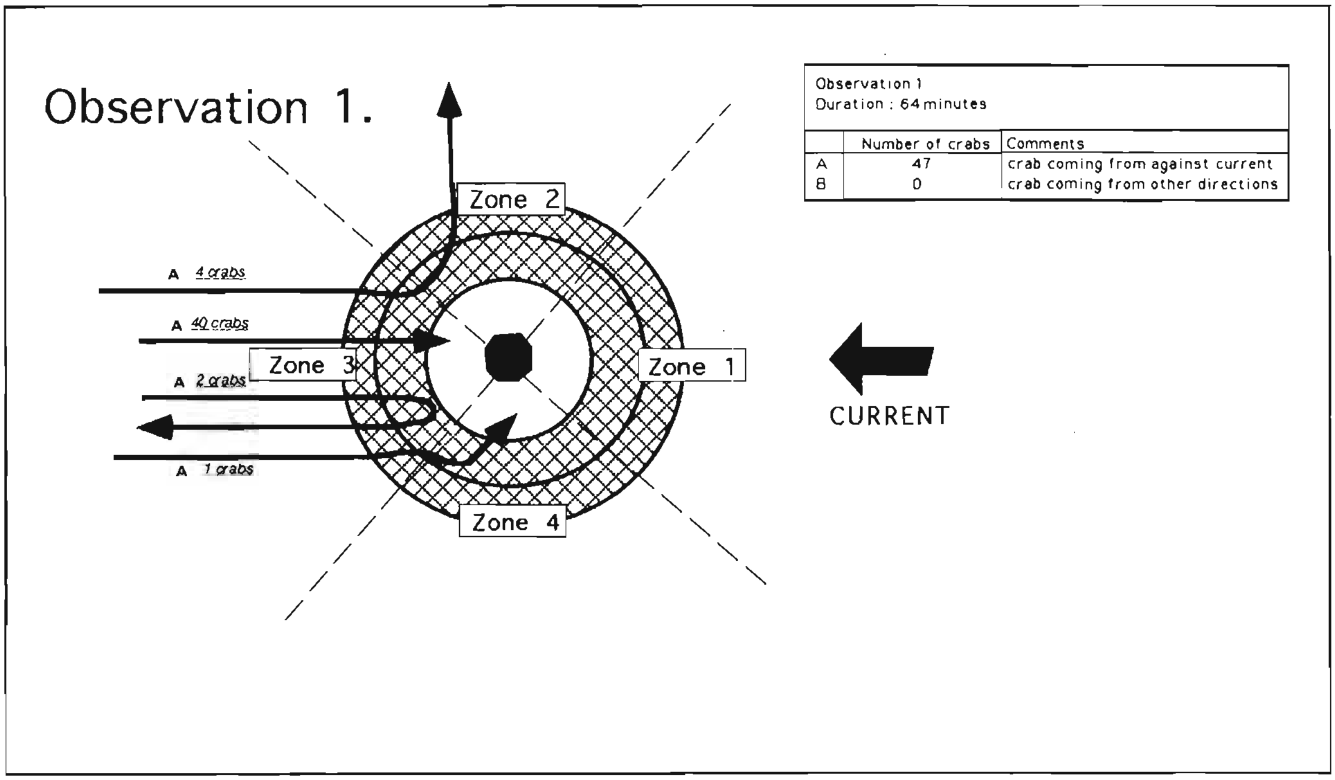


Figure 5. Hypothetical attraction area formation "attraction strip".

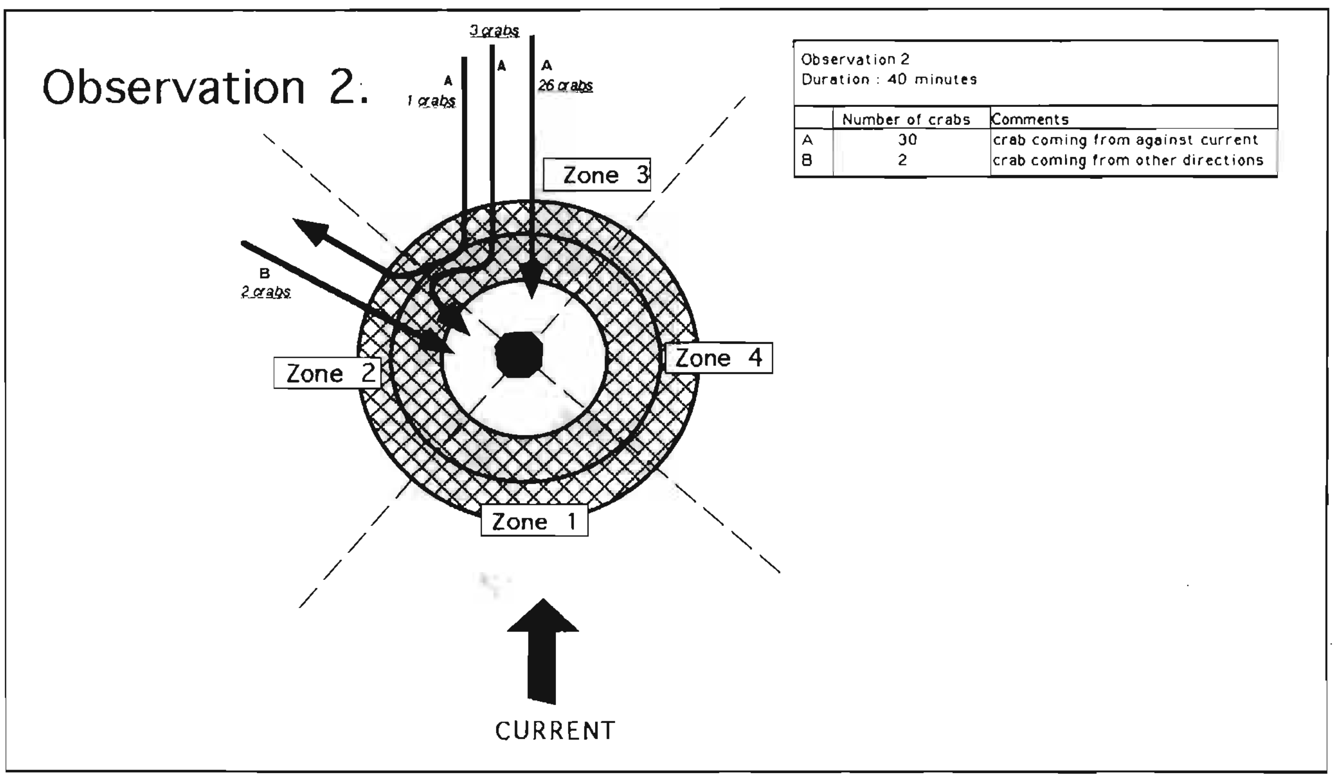
Figure 6a.



Observation 1
Duration : 64 minutes

	Number of crabs	Comments
A	47	crab coming from against current
B	0	crab coming from other directions

Figure 6b.



Observation 2
Duration : 40 minutes

	Number of crabs	Comments
A	30	crab coming from against current
B	2	crab coming from other directions

Figure 6. Recorded sequence of snow crab (Chionoecetes opilio) movement in relation to current direction from a top view of a conical snow crab trap, baited at centre.

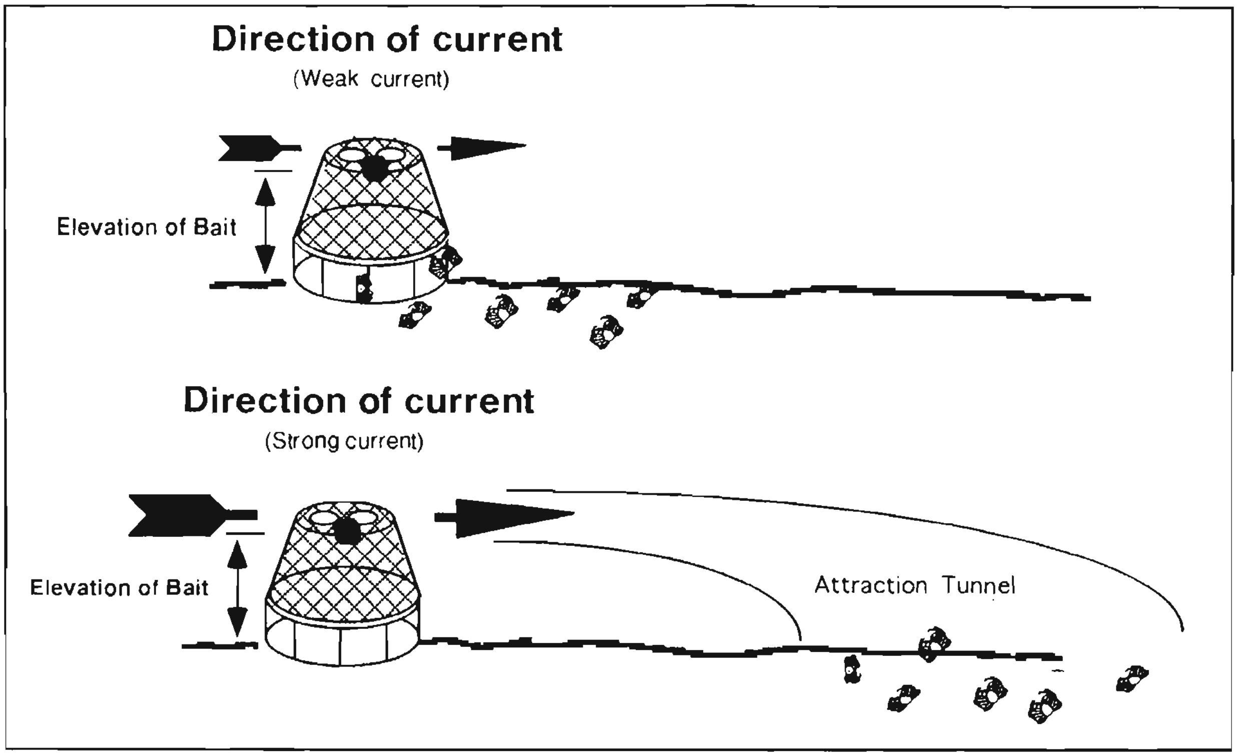


Figure 7. Hypothetical attraction area formation "Attraction Tunnel" with elevated bait.

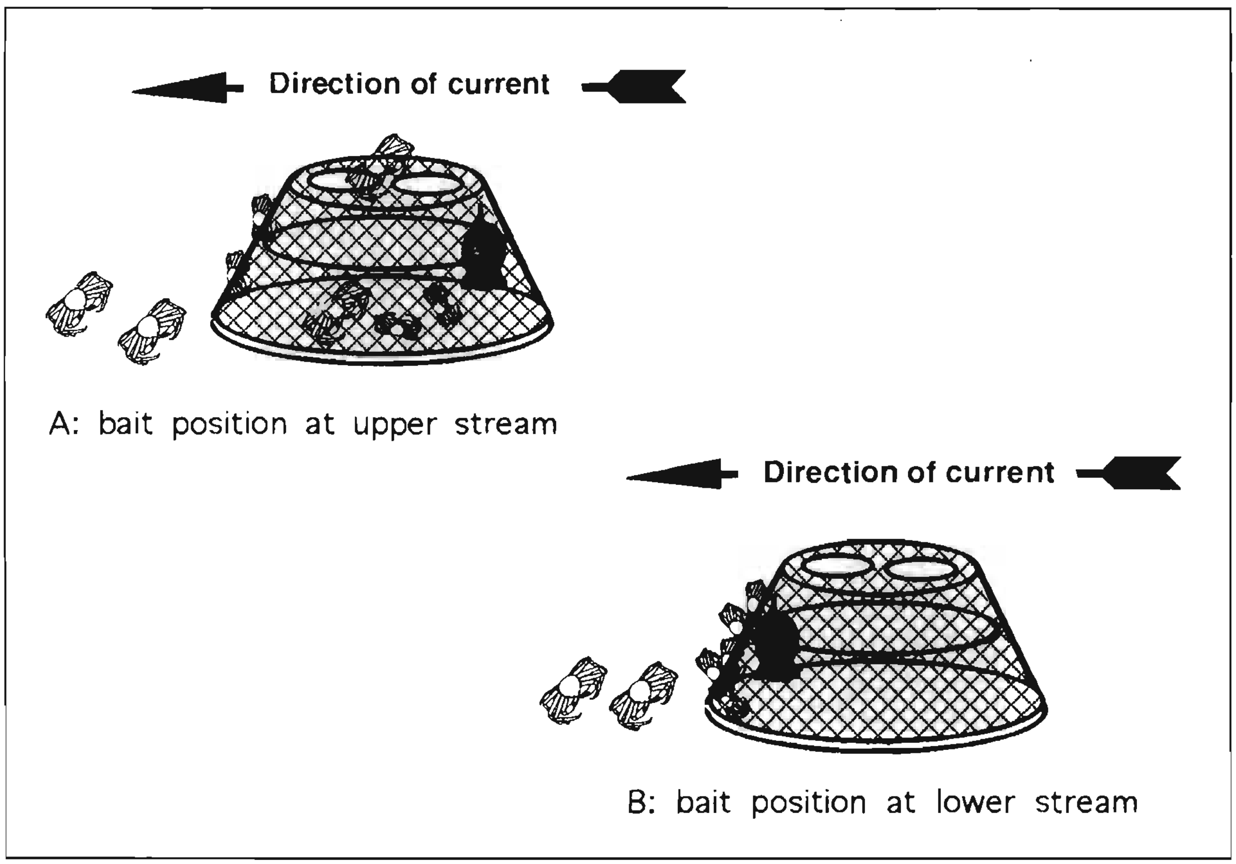


Figure 8. Bait position and current versus capture of snow crab (<u>Chionoecetes opilio</u>).

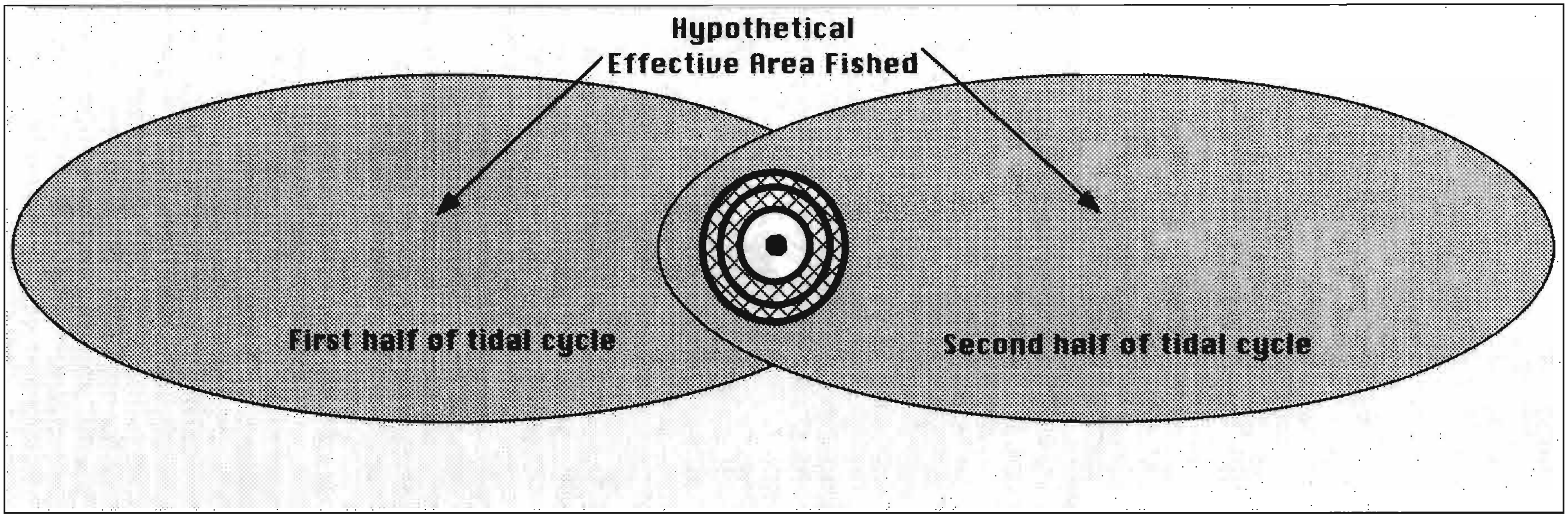


Figure 9. Hypothetical attraction area by a conical snow crab (Chionoecetes opilio) trap for a duration of one complete tidal cycle.