Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

Evaluation of catch selectivity of modified snow crab (Chionoecetes opilio) conical traps.

Y.J. Chiasson, R. Vienneau, P. DeGrâce, R. Campbell, M. Hébert and M. Moriyasu

Department of Fisheries and Oceans
Gulf Fisheries Centre
P.O. Box 5030
Moncton, New Brunswick
E1C 9B6

July 1993

Canadian Technical Report of Fisheries and Aquatic Sciences No. 1930

Fisheries and Oceans
Pêches et Océans

Canada

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457–714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715–924 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Technical Report of Fisheries
and Aquatic Sciences No. 1930

July 1993

Evaluation of catch selectivity of modified snow crab, (*Chionoecetes opilio*) conical traps. [1]

by

Y.J. Chiasson, R. Vienneau, P. DeGrâce, R. Campbell, M. Hébert
and M. Moriyasu

Department of Fisheries and Oceans
Gulf Fisheries Centre
P.O. Box 5030
Moncton, New Brunswick
E1C 9B6

1. This project was conducted under the gear conversion project of the Atlantic Fisheries Adjustment Program (AFAP # A92GF010)

Cat. no. Fs97-6/1930E ISSN 0706-6457

Correct citation for this publication is:

Chiasson,Y.J., R. Vienneau, P. DeGrâce, R. Campbell, M. Hébert and M. Moriyasu. 1993. Evaluation of catch selectivity of modified snow crab (Chionoecetes opilio) conical traps. Can. Tech. Rep. Fish. Aquat. Sci. 1930: 21 p.

ABSTRACT

Chiasson,Y.J., R. Vienneau, P. DeGrâce, R. Campbell, M. Hébert and M. Moriyasu. 1993. Evaluation of catch selectivity of modified snow crab (Chionoecetes opilio) conical traps. Can. Tech. Rep. Fish. Aquat. Sci. 1930: 21 p.

The snow crab (Chionoecetes opilio) fishery in the southwestern Gulf of St. Lawrence depends almost exclusively on annual recruitment (snow crab newly molted to commercial size). The fishery is therefore extremely sensitive to yearly fluctuations in the number of individuals reaching the minimum legal size. The protection of this annual recruitment, undersized juveniles and females, is a prerequisite for rebuilding the depressed stock. If a selective trap mechanism can be installed on conventional traps, the protection of soft, undersized juvenile and female crab can be largely enhanced with lesser resources. This study demonstrated that the number of soft and undersized crab caught in the conventional conical traps modified by a selective mechanism generally decreased with the increased integrated panel height. Also, the CPUE's of commercial size crab increased for the modified 1/2LV and 2LV traps compared to the normal conical traps. The mean size of legal size crab did not change with the panel height except for the 3LV trap that caught significantly larger crab than the other types.

RÉSUMÉ

Chiasson,Y.J., R. Vienneau, P. DeGrâce, R. Campbell, M. Hébert and M. Moriyasu. 1993. Evaluation of catch selectivity of modified snow crab (Chionoecetes opilio) conical traps. Can. Tech. Rep. Fish. Aquat. Sci. 1930: 21 p.

La pêche au crabe des neiges (Chionoecetes opilio) dans le sud-ouest du golfe du Saint-Laurent depend presqu'exclusivement du recrutement annuel (crabes nouvellement mués à la taille commerciale). Cette pêcherie est donc très sensible aux fluctuations annuelles du nombre d'individus atteignant la taille légale minimale. La protection de ce recrutement annuel, des juvéniles de taille sous-légale et de femelles est donc primordial afin de rebâtir les stocks. Si un mécanisme sélectif peut être installé sur les casiers conventionnels, la protection de crabe mou, de juvéniles de taille sous-légale ainsi que des femelles pourrait être assurée avec moins de ressources. Cette étude a démontré que le nombre de crabes mous et de taille sous-légale capturés dans les casiers conventionels munis d'un mécanisme sélectif diminue généralement avec l'augmentation de la hauteur du panneau intégré au casier. Aussi, la PUE des crabes de taille commerciale des casiers modifiés 1/2LV et 1LV a augmenté comparé au casier normal. La taille moyenne des crabes de taille légale n'a pas été affecté par la hauteur du panneau excepté pour les casiers modifiés 3LV qui ont capturé des crabes de taille significativement plus grandes que les autres types de casiers modifiés.

INTRODUCTION

In the Gulf of St. Lawrence, the crab industry relies on hard shelled males which have molted one year or more prior to exploitation. At an early state of exploitation, most individuals captured in the southern Gulf of St. Lawrence were hard shelled morphometrically mature (large claw) males accumulated over a period of 2 to 3 years. As the fishery developed, old large claw males were fished out and the proportion of individuals which had molted immediately prior to the fishing season increased in the commercial catch (Hébert et al. 1992).

The southwestern Gulf of St. Lawrence (zone 12 shown in Fig. 1) is one of the most productive snow crab fishing zones in eastern Canada. The minimum legal size is set at 95 mm carapace width (c.w.) and the females are not harvested. In 1987-1988, the snow crab landings for zone 12 dropped drastically by half to about 12000 t, which was the lowest level recorded since 1978. In 1989, the landings decreased further to 7900 t due to the premature closure of the fishery as a result of a high incidence of newly molted soft shelled crab in the catches. Since 1990, the fishery in the southwestern Gulf of St. Lawrence has been restricted to the spring when the Gulf is free of ice, and a rigorous management strategy was instituted to rebuild the depressed snow crab stock. One of these measures was the closure of the fishing season when the catch at sea of soft shell crab for two consecutive weeks was over 20 percent (in numbers) based on the carapace hardness. This measure was enforced to diminish the fishery induced mortality of newly molted crab which are the only renewable part of the stock and therefore will constitute an important part of the future exploitable stock.

These recently recruited soft shelled crabs have a low commercial value and are discarded at sea with a subsequent high fishery induced mortality. The high exploitation and subsequent depletion of old shell crab in the fishery creates a dependency on the annual recruitment to the fishery. The landings then fluctuate in response to this annual recruitment.

Since 1986, the conical trap has been the most popular trap used by the snow crab fishermen in the southwestern Gulf of St. Lawrence (Chiasson et al. 1992). The introduction of a selective snow crab trap that reduces the capture of soft, illegal size and female crab would benefit the fishing industry, diminish the costs associated with observers for DFO and enhance the annual recruitment. Also, the market has introduced a price variance for a different size of snow crab. When a fishermen is limited to a quota, even the snow crab of legal size would be thrown back at sea to maximize the fishermen's revenue. An appropriate selective trap would then leave the non desirable crab on the sea bottom.

Observations from aquarium experiments showed that plastic panels attached to the conventional conical trap discourage crab from climbing a slope comparable to that of the sides of conventional conical snow crab traps. The purpose of this study was to evaluate the selectivity of modified conical traps relative to snow crab size and carapace hardness.

MATERIALS AND METHODS

FIRST EXPERIMENT

A commercial crab vessel was chartered to conduct experimental fishing in the Baie des Chaleurs (Fig. 2) during the 1991 crab fishing season.

Three different heights of panel were used, based on the length (from tip to tip) of the extended walking legs of a male crab of minimum legal size. The three panel heights installed on the slope of the traps (LS) were 25% of this length , which corresponded to 12.5 cm (1LS), 50% equalling 25 cm (2LS) and 75% for 37.5 cm (3LS). These panels were perforated on the edges and installed at the bottom of the trap slope, with fishing twine or straps (Fig. 3). The panels were positioned in such a way as to discourage the smaller size crab from entering the traps through the web at the bottom of the slope.

Thirty (30) conical traps (10 modified traps for each panel height) were added to a commercial fishermen's 150 non-modified conventional conical traps and were sampled at lease once a week. The selectivity of the modified traps was also monitored after the closure of the fishing season from July 2 to July 23, 1991. Each trap was baited with 2 kg of fresh mackerel (Scomber scombrus) placed in a mesh bag and attached to the center of the trap to eliminate the current effect on catchability (Vienneau et al. 1993). Captured crabs were enumerated, sexed, and measured for carapace width and chela height to the nearest millimeter. The carapace hardness of each male crab was taken with a hardness gauge (durometer), as described by Foyle et al. (1989).

Observations were also monitored and recorded with an underwater video camera system (Fig. 4) for all the above modified traps and also on conventional conical traps to better understand their catchability characteristics (Vienneau et al. 1993).

Conical traps with plastic panels relocated to the upper part of the angle slope and an adjustable elevated conical trap (Fig. 3) were also observed with the underwater video camera for its performance and selectivity.

SECOND EXPERIMENT

Based on preliminary results of the first experiment, a second experiment was set up to examine trap selectivity. The panel was removed from the slope of the conical trap, and incorporated vertically (Fig. 3) at the top of the conical trap. Four different heights on the vertical (LV) for this new design (1/2LV=6 cm, 1LV=12 cm, 2LV=18 cm and 3LV=24 cm) were tested and monitored with the underwater video camera system.

Three sets of 5 traps, composed of 1/2 LV, 1LV, 2LV, 3LV and one conventional conical trap were sampled periodically after the 1992 crab fishing season in the Baie des Chaleurs. A total of 26 sets were sampled.

Statistical data analysis:

The size frequency distributions for each type of trap were compared between trap types by the Kolmogorov-Smirnov two sample test. The mean carapace widths of all samples for both sexes as well as legal (≥95 mm c.w.) and sublegal (<95 mm c.w.) size males were also compared between trap types by the t-test.

Catch per unit effort (CPUE, as number of crab per trap haul) for soft and sub-legal size males were calculated for each trap type, and also the CPUE's (as number and weight of crab per trap haul) of legal size males were calculated for each trap type because the catch weight of legal size males is the basis by which fishermen would evaluate the efficiency of the different trap type. The size-weight relationship for male crab used to obtain a CPUE in weight was calculated from data collected from an independant trawl survey conducted in Baie des Chaleurs. A predictive linear regression was fitted by least squares to each set of paired data for carapace width (mm) and wet body weight (g) after logarithmic transformation. Body weight (g) = $2.746 \cdot 10^{-4}$ x [carapace width (mm)]$^{3.1}$
All data sets were analysed by Bartlet's chi-square test for homogeneity of variance and then compared by ANOVA to determine if there are significant differences in the CPUE's among trap type.

Underwater video observations:

A metal frame was constructed to support the video camera, the lights and the pan and tilt mechanism above the conical traps to observe crab behaviour (Fig. 4). 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 attendant 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.

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 degrees horizontal and 81 degrees vertical capacity compared to the pipe camera providing only 47 degrees 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 was done at depths ranging from 80 to 90 m. Monitoring time with periodic resettting of the trap on the sea bottom varied from 2 to 14 h, up to 6 h of continuous observations 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 in observing crabs approaching the trap downstream side (opposite direction) of the current (Vienneau et al. 1993).

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.

RESULTS

FIRST EXPERIMENT

Underwater camera observations:

The characteristics of the crab that could be determined visually from our remote black and white monitor were the sex and its approximate size. Crab shell condition could not be determined visually. The amount of crab monitored was proportional to the abundance of crab in the area and to the strength of the bottom current (Vienneau et al.1993) which influences the bait attraction area.

The 1LS and 2LS modified conical traps did not show any changes in this attraction area since the bait was hung at approximately 30 cm off bottom and above the panels exposing it to bottom current. For the 3LS panel (37.5 cm), the bait was enclosed by the panels and, although crab movements were observed around the trap, the effective area fished was assumed to be more limited since the current would not be expected to displace the bait odour as much as the open web conical trap.

Although the 1LS panel height did not discourage the capture of females or small crab, some selectivity was noted when the panel height was increased to 2LS and 3LS. From the bottom of the trap, crabs climbed over each other and consequently some small crab were able to reach over the panel to the web on the slope of the conical trap to eventually be captured. Since the selective panel was at the bottom of the conical trap covering the mesh, once captured, there was no escape for these small crab.

A considerable number of the modified traps flipped upside down when deployed at sea in the usual fishing way. The water friction on the selective panel installed on the angle slope of the conical trap made it reverse like a funnel (Fig. 5). This was noticed when many traps were pulled up and had mud on the top and a low number of crab captured. Relocating the selective panel to the top of the slope (Fig. 2) avoided this problem. Although it did not stop the reversal of the trap at bottom, it improved the selectivity performance of the trap. The stacking of crab near the panel was impossible due to the steep slope and if small crab were captured, they could escape through the web at the bottom of the trap.

Due to the forementionned problems with the traps and their deployment, no statistical analyses were done on the traps equipped with panels on the slope.

SECOND EXPERIMENT

Trap design:

In the summer of 1992, a new set of modified traps (Fig. 3) were designed to ensure the trap placement was the right side up. Observations with an underwater video camera showed that larger crab were caught with an increase in the height of the vertical panel.

Size comparisons:

The size frequency distributions of male crab (Fig. 6) caught from the five different types of trap were compared by use of the Kolmogorov-Smirnov test (Table 1). The values of D and p are presented in Appendix 1. The size frequency distributions of male crab were significantly different between Normal and all other traps, 1/2LV traps and 3LV traps, 1LV traps and 3LV traps and also between 2LV traps and 3LV traps. No significant difference was found between 1/2LV traps and 1LV traps, 1/2LV traps and 2LV traps and also between 1LV traps and 2LV traps. The size frequency distributions of female snow crab were similar for all sets of traps (Table 2) except between Normal and 2LV traps and between 1/2LV traps and 2LV traps which were significantly different.

The mean carapace width of males was different for the five different types of traps used when compared by t-test. The values of t, p and the number of degrees of freedom are presented in Appendix 2. The mean carapace width of males collected from normal conical traps (97.22 mm) was significantly smaller than all other traps (1/2LV=101.03 mm, 1LV=101.1 mm, 2LV=100.03 mm and 3LV =104.4 mm). The 3LV trap caught significantly larger crab (104.4 mm) than all other traps. No significant differences were found between the mean size of male crab of 1/2LV traps versus 1L traps and 2LV traps and also between 1LV traps versus 2LV traps.

No significant differences were found in the mean carapace width of legal size males collected from normal conical traps (109.76 mm) when compared by t-test versus 1/2LV traps (109.31 mm), 1LV traps (109.58 mm), 2LV traps (109.04 mm) and 3LV traps (110.77 mm). There were also no significant differences between 1/2LV traps and 1LV traps, 1/2LV traps and 2LV traps and between 1LV traps and 2LV traps. 3LV traps caught significantly larger crab than any of the other modified traps.

The mean carapace width of sublegal males collected from normal conical traps (84.43 mm) when compared by t-test was significantly smaller than all other traps (1/2LV=85.79 mm,1LV=86.31 mm, 2LV=85.46 mm and 3LV=87.01 mm). The 3LV trap caught significantly larger sublegal crab (87.01 mm) than 1/2LV traps and than 2LV traps. No significant differences were found between the mean size of sublegal male crab of 1/2LV traps versus 1LV traps and 2LV traps and also between 1LV traps versus 2LV traps and versus 3LV traps.

The results of comparisons of size structure and mean size between trap types are summarized as follows:

Comparison	Mean carapace width Total	≥95 mm	<95 mm	Size structure males	females
Normal vs 1/2LV	*	-	*	*	-
Normal vs 1LV	*	-	*	*	-
Normal vs 2LV	*	-	*	*	*
Normal vs 3LV	*	-	*	*	-
1/2LV vs 1LV	-	-	-	-	-
1/2LV vs 2LV	-	-	-	-	*
1/2LV vs 3LV	*	*	*	*	-
1LV vs 2LV	-	-	-	-	-
1LV vs 3LV	*	*	-	*	-
2LV vs 3LV	*	*	*	*	-

* significantly different ; - Not significantly different ($p<0.05$)

CPUE **comparisons:**

The variance of the CPUE values (in number and weight of crab per trap) for males were homoscedastic ($p<0.05$) for all sets. The data sets were therefore compared by ANOVA (Table 3). The values of t, p and the number of degrees of freedom are presented in Appendix 3.

The normal conical traps caught significantly more soft crab in number (21.54 crabs) than the 1LV traps (14.19 crabs), the 2LV traps (11.12 crabs), and the 3LV traps (11.31 crabs). No significant difference was found in the mean CPUE in number of soft crab per trap between 1/2 LV traps (17.15 crabs) versus normal conical traps, 1LV traps, and 3LV traps. However the 1/2LV trap caught significantly more soft crab (17.15 crabs) than the 2LV (11.12 crabs). No significant differences in the mean number of soft crab was found between 1LV traps versus 2LV traps and 3LV traps and between 2LV traps and 3LV traps.

The mean CPUE's in number of legal size hard shell crab were different among the five different types of trap (Table 3). No significant differences were found between normal conical traps (20.27 crabs) versus 1/2 LV (21.85 crabs), 1LV (20.5 crabs), 2LV (14.65 crabs) and 3LV (15.69 crabs). No significant differences were found between 1/2 LV versus 1LV and between 2LV and 3LV. The CPUE in number of legal size hard shell crab was significantly higher for the 1/2LV traps versus 2LV traps and versus 3LV traps (15.69 crabs). The CPUE was also higher for the 1LV traps versus the 2LV traps and the 3LV traps.

The mean CPUE in weight of legal size hard shell crab were different among the five different types of trap (Table 3). No significant differences were found between normal conical traps (11.5 kg) versus 1/2 LV (12.19 kg), 1LV (11.52 kg), 2LV (8.28 kg) and 3LV (9.07 kg). No significant differences were found between 1/2 LV versus 1LV and between 3LV versus 1LV and versus 2LV. The CPUE in weight of legal size hard shell crab was significantly higher for the 1/2LV traps versus 2LV traps and versus 3LV traps. The CPUE was also higher for the 1LV traps versus the 2LV traps.

The mean CPUE's in number of sublegal size males (<95 mm c.w.) were different among the five types of traps (Table 3). No significant differences were found between the normal trap (13.77 crabs) versus the 1/2LV traps (9.42 crabs) and versus the 1LV traps (10.23 crabs). However, the CPUE was significantly lower for the 2LV traps (6.27 crabs) and the 3LV traps (5.19 crabs) compared to the normal traps. The mean CPUE was not significantly different between 1/2 LV traps versus 1LV traps, and versus 2LV traps but was significantly higher than the 3LV traps. The 1LV traps caught significantly more sublegal size crab than the 2LV traps and the 3LV traps. No differences were found between the CPUE of the 2LV traps and the 3LV traps.

The results of comparisons of CPUE of males in number and weight between trap types are summarized as follows:

	CPUE in number			CPUE in weight
Comparison	Soft	hard ≥95 mm	hard <95 mm	≥ 95 mm
Normal vs 1/2LV	-	-	-	-
Normal vs 1LV	*	-	-	-
Normal vs 2LV	*	-	*	-
Normal vs 3LV	*	-	*	-
1/2LV vs 1LV	-	-	-	-
1/2LV vs 2LV	*	*	-	*
1/2LV vs 3LV	-	*	*	*
1LV vs 2LV	-	*	*	*
1LV vs 3LV	-	*	*	-
2LV vs 3LV	-	-	-	-

* significantly different ; - Not significantly different ($p<0.05$)

DISCUSSION AND CONCLUSION

The present study showed that the five different types of trap have different catch characteristics both in terms of quality and quantity of crab caught. The size distributions were significantly different for some paired comparisons between different trap types, which was mainly due to the difference in size distribution of sublegal crabs.

This study demonstrated that the number of soft and undersized crab caught in the conical traps generally decreased with the increased height of the panel of the modified traps (Table 3). Also, the CPUE's in number and in weight of commercial size crab increased for the 1LV and 1/2LV traps compared to the normal conical traps. The 1LV trap caught 34% less soft crab, 32% less small males and although the difference is not significant, caught more legal size hard shelled crab in number and in weight than the normal conical trap. The 1/2 LV trap was a little less efficient in avoiding the catch of soft and undersized crab and was more efficient than the normal conical trap for capturing legal size hard shell crab (Fig. 7). The mean size of legal size crab did not change with the panel height except for the 3LV trap that caught significantly larger crab than the other types.

The latest design of modified conical trap (vertical panel) is therefore a good alternative to explore in designing a trap that could diminish the capture of undesired (undersized, soft and female) crabs while not affecting and even improving the catch of hard shell legal size crabs. The possibility of capturing different biological categories of crabs by modifying the trap could be very interesting in order to target the capture of a certain group of crab because of market conditions or for the protection of the resource.

Several factors such as the ease of handling (weight, ability to stack), catch rate of legal size crab and the replacement cost have to be taken into consideration if the new trap type is to be accepted by the fishing industry.

ACKNOWLEDGEMENTS

The authors would like to thank Angelbert Paulin and the crew of the PRAGA for their work at sea, Allain Noël, Florence Albert and André-Marc Lanteigne for their financial and administrative support, Maurice St.-Pierre, Yves Hébert and Rémi Mallet for their technical assistance in this project. Special thanks go to Sharon McGladerry and Kevin Davidson for reviewing the manuscript.

REFERENCES

Chiasson, Y.J., M. Hébert, M. Moriyasu, A. Bourgoin and D. Noël. 1992. A retrospective look at the development and expansion of the Southwestern Gulf of St. Lawrence snow crab, Chionoecetes opilio, fishery. Can. Tech. Rep. Fish. Aquat. Sci. 1847: 23 p.

Conan, G.Y., D.R. Maynard, A. Merrien and Y. Guennegan. 1984. Monitoring the foraging activity of lobsters and associated species by underwater television. ICES Shellfish Committee C.M. 1984/K: 45, 13 p.

Foyle, T.P., G.V. Hurley, and D.M. Taylor. 1989. Field testing shell hardness gauges for the snow crab fishery. Can. Ind. Rep. Fish. Aquat. Sci. 193: 38 pp.

Hébert, M., C. Gallant, Y. Chiasson, P. Mallet, P. DeGrâce and M. Moriyasu. 1992. Le suivi du pourcentage de crabes mous dans les prises commerciales de crabe des neiges (Chionoecetes opilio) dans le sud-ouest du golfe du Saint-Laurent (zone 12) en 1990 et 1991. Can. Tech. Rep. Fish. Aquat. Sci. 1886: 18 p.

Vienneau, R., A. Paulin and M. Moriyasu. 1993. Evaluation of the catch mechanism of conventional conical snow crab (Chionoecetes opilio) traps by underwater video camera observations. Can. Tech. Rep. Fish. Aquat. Sci. 1903: 15 p.

Table 1. Results of Kolmogorov-Smirnov test for comparison of male size frequency distributions between different types of traps.

Normal vs 1/2LV

DF	2	
Normal cases	1610	
1/2LV cases	1358	
Maximum difference	.14	
K-S Chi Square	60.29	
Z	3.88	p=.0001

Normal vs 1LV

DF	2	
Normal cases	1610	
1LV cases	1276	
Maximum difference	.13	
K-S Chi Square	51.05	
Z	3.57	p=.0004

Normal vs 2LV

DF	2	
Normal cases	1610	
2LV cases	909	
Maximum difference	.12	
K-S Chi Square	32.64	
Z	2.86	p=.0043

Normal vs 3LV

DF	2	
Normal cases	1610	
3LV cases	903	
Maximum difference	.23	
K-S Chi Square	120.32	
Z	5.48	p=.0001

1/2LV vs 1LV

DF	2	
1/2LV cases	1358	
1LV cases	1276	
Maximum difference	.01	
K-S Chi Square	.59	
Z	0.38	p=.7012

1/2LV vs 2LV

DF	2	
1/2LV cases	1358	
2LV cases	909	
Maximum difference	.03	
K-S Chi Square	2.62	
Z	0.81	p=.418

1/2LV vs 3LV

DF	2	
1/2LV cases	1358	
3LV cases	903	
Maximum difference	.11	
K-S Chi Square	27.76	
Z	2.63	p=.0084

1LV vs 2LV

DF	2	
ILV cases	1276	
2LV cases	909	
Maximum difference	.04	
K-S Chi Square	2.88	
Z	0.85	p=.3961

1LV vs 3LV

DF	2	
ILV cases	1276	
3LV cases	903	
Maximum difference	.11	
K-S Chi Square	25.60	
Z	2.53	p=.0114

2LV vs 3LV

DF	2	
2LV cases	909	
3LV cases	903	
Maximum difference	.14	
K-S Chi Square	35.71	
Z	2.99	p=.0028

Table 2. Results of Kolmogorov-Smirnov test for comparison of female size frequency distributions between different types of traps.

Normal vs 1/2LV

DF	2	
Normal cases	140	
1/2LV cases	62	
Maximum difference	.14	
K-S Chi Square	3.47	
Z	0.93	p=.3514

Normal vs 1LV

DF	2	
Normal cases	140	
1LV cases	23	
Maximum difference	.22	
K-S Chi Square	3.66	
Z	0.96	p=.3388

Normal vs 2LV

DF	2	
Normal cases	140	
2LV cases	53	
Maximum difference	.48	
K-S Chi Square	35.7	
Z	2.99	p=.0028

Normal vs 3LV

DF	2	
Normal cases	140	
3LV cases	11	
Maximum difference	.43	
K-S Chi Square	7.58	
Z	1.38	p=.1685

1/2LV vs 1LV

DF	2	
1/2LV cases	62	
1LV cases	23	
Maximum difference	.17	
K-S Chi Square	1.95	
Z	0.70	p=.4852

1/2LV vs 2LV

DF	2	
1/2LV cases	62	
2LV cases	53	
Maximum difference	.39	
K-S Chi Square	17.05	
Z	2.06	p=.039

1/2LV vs 3LV

DF	2	
1/2LV cases	62	
3LV cases	11	
Maximum difference	.38	
K-S Chi Square	5.52	
Z	1.17	p=.2403

1LV vs 2LV

DF	2	
IL cases	23	
2LV cases	53	
Maximum difference	.36	
K-S Chi Square	8.13	
Z	1.43	p=.1539

1LV vs 3LV

DF	2	
IL cases	23	
3LV cases	11	
Maximum difference	.46	
K-S Chi Square	6.26	
Z	1.25	p=.211

2LV vs 3LV

DF	2	
2LV cases	53	
3LV cases	11	
Maximum difference	.25	
K-S Chi Square	2.29	
Z	0.76	p=.4497

Table 3. Statistics and results of ANOVA test for comparison of CPUE's in number and in weight among five different types of trap.

1. CPUE's in number of male crab with soft carapace.

Source	D.f.	Sum Squares	Mean Square	F-test
Between groups	4	1995.43	498.86	4.06
Within groups	125	15340.08	122.72	p=.0039
Total	129	17335.51		
Group	**Count**	**Mean**	**Std. Dev.**	**Std. Err.**
Normal	26	21.54	16.33	3.20
1/2LV	26	17.15	12.47	2.45
1LV	26	14.19	7.63	1.50
3LV	26	11.31	8.97	1.76
2LV	26	11.12	7.25	1.42

2. CPUE's in number of hard shelled male crab <95 mm carapace width.

Source	D.f.	Sum Squares	Mean Square	F-test
Between groups	4	1206.20	301.55	7.47
Within groups	125	5044.73	40.36	p=.0001
Total	129	6250.93		
Group	**Count**	**Mean**	**Std. Dev.**	**Std. Err.**
Normal	26	13.77	8.49	1.67
1LV	26	10.23	5.69	1.12
1/2LV	26	9.42	8.17	1.6
3LV	26	6.27	4.44	0.87
2LV	26	5.19	3.29	0.64

Table 3. Cont.

3. CPUE's in number of hard shelled male crab ≥95 mm carapace width.

Source	D.f.	Sum Squares	Mean Square	F-test
Between groups	4	1064.97	266.24	2.5
Within groups	125	13308.42	106.47	p=.0458
Total	129	14373.39		
Group	Count	Mean	Std. Dev.	Std. Err.
1/2LV	26	21.85	12.08	2.37
1LV	26	20.50	9.28	1.82
Normal	26	20.27	12.51	2.45
3LV	26	15.69	7.37	1.45
2LV	26	14.65	9.45	1.85

4. CPUE's in weight of hard shelled male crab ≥95 mm carapace width.

Source	D.f.	Sum Squares	Mean Square	F-test
Between groups	4	308.64	77.16	2.32
Within groups	125	4152.54	33.22	p=.0603
Total	129	4461.18		
Group	Count	Mean	Std. Dev.	Std. Err.
1/2LV	26	12.19	6.59	1.29
1LV	26	11.52	5.06	0.99
Normal	26	11.50	7.31	1.43
3LV	26	9.07	4.09	0.80
2LV	26	8.28	5.19	1.02

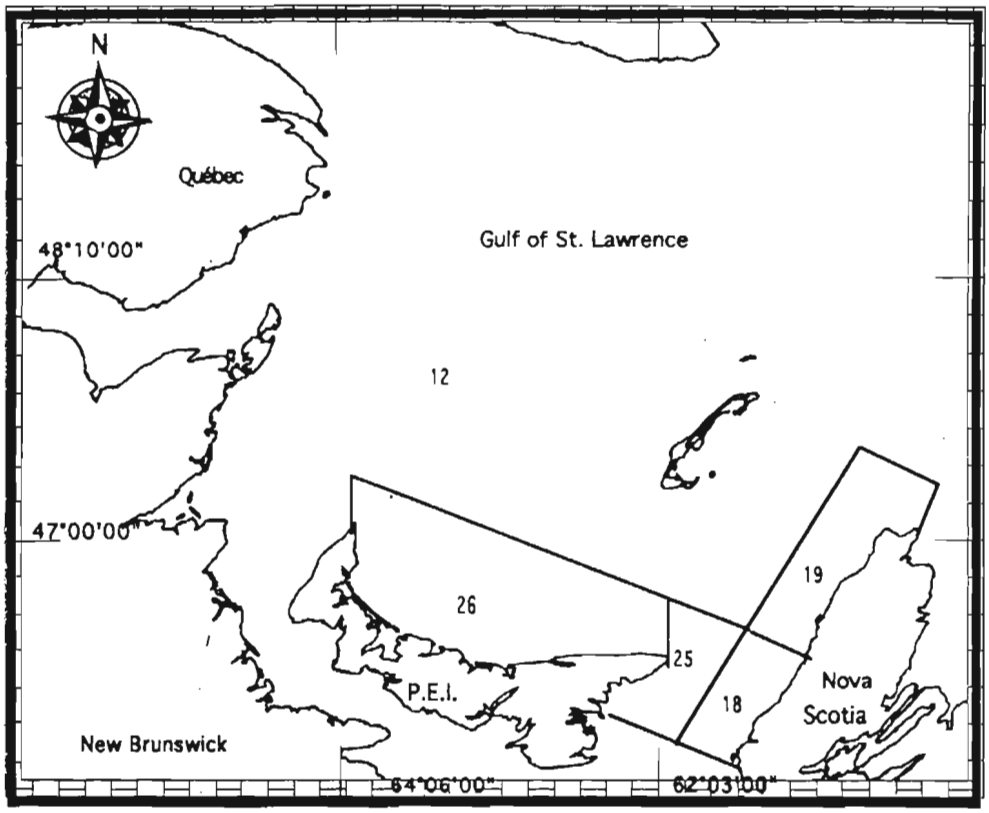


Figure 1. Southern Gulf of St. Lawrence snow crab, Chionoecetes opilio, management zones.

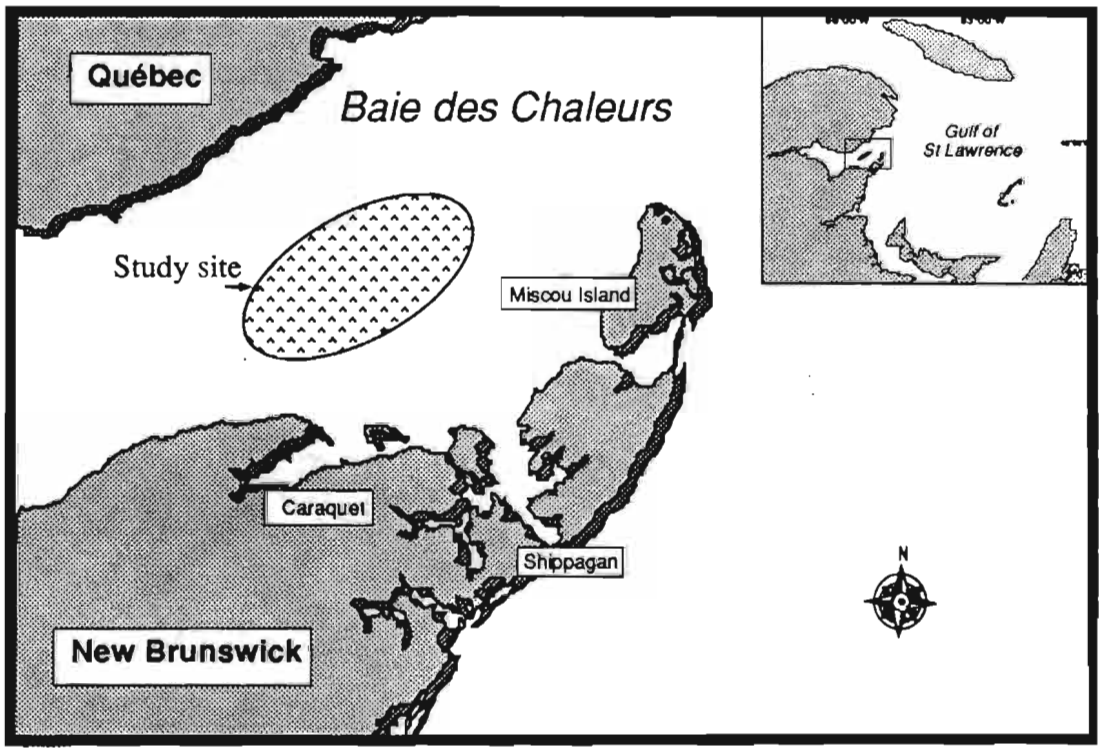
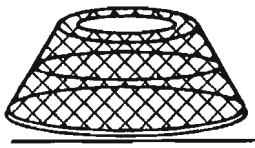
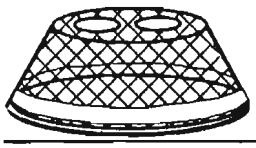


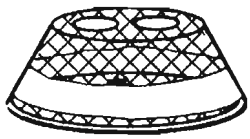
Figure 2. Study site of the trap selectivity project in Baie des Chaleurs.



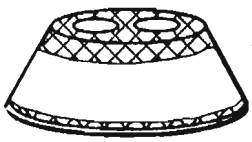
Normal (conventional) Conical Trap



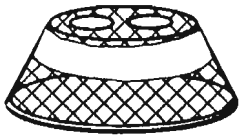
1991 - First Experiment
1LS * Angle panel of 12.5 cm equalling 25% of the morphometry lenght from tip to tip of the walking legs from a male crab of minimum legal size (95 mm).



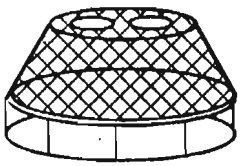
1991 - First Experiment
2LS * Angle panel of 25 cm equalling 50% of the morphometry lenght from tip to tip of the walking legs from a male crab of minimum legal size (95 mm).



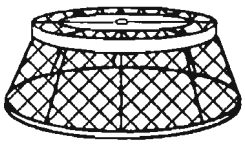
1991 - First Experiment
3LS * Angle panel of 37.5 cm equalling 75% of the morphometry lenght from tip to tip of the walking legs from a male crab of minimum legal size (95 mm).



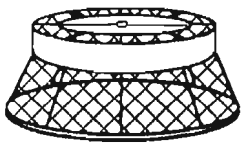
1991 - First Experiment
Angle panel relocated in the upper part of the angle slope of the conical trap.



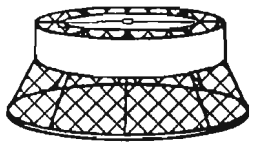
1991 - First Experiment
Elevated conical trap with adjustable legs to vary it's height.



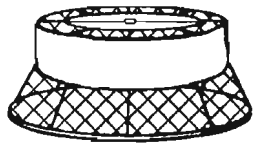
1992 - Second Experiment
1/2LV * Vertical panel height of 6 cm.



1992 - Second Experiment
1LV * Vertical panel height of 12 cm.



1992 - Second Experiment
2LV * Vertical panel height of 18 cm.



1992 - Second Experiment
3LV * Vertical panel height of 24 cm.

*LS = Length on the slope *LV = Length on the vertical

Figure 3. Type of traps and location of panels used in the 1991 and 1992 gear selectivity project.

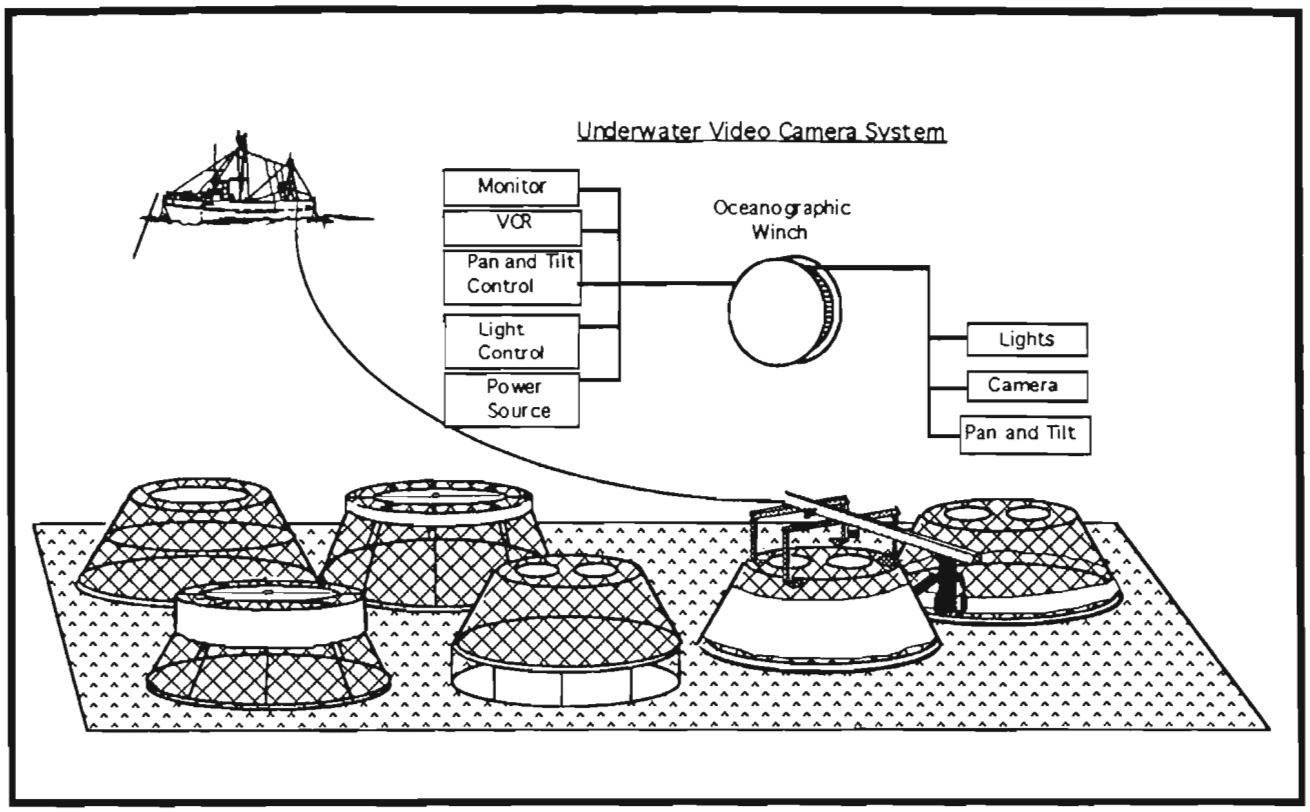
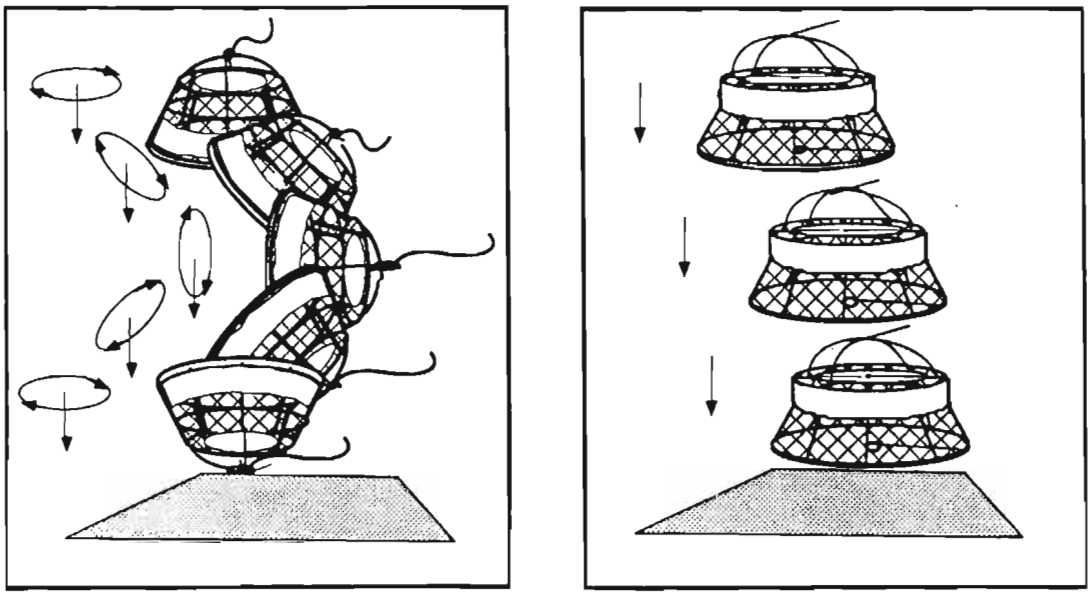


Figure 4. Block diagram of the underwater video camera system.



A. Panel on the slope

B. Panel on the vertical

Figure 5. Water friction effect on modified conical traps.

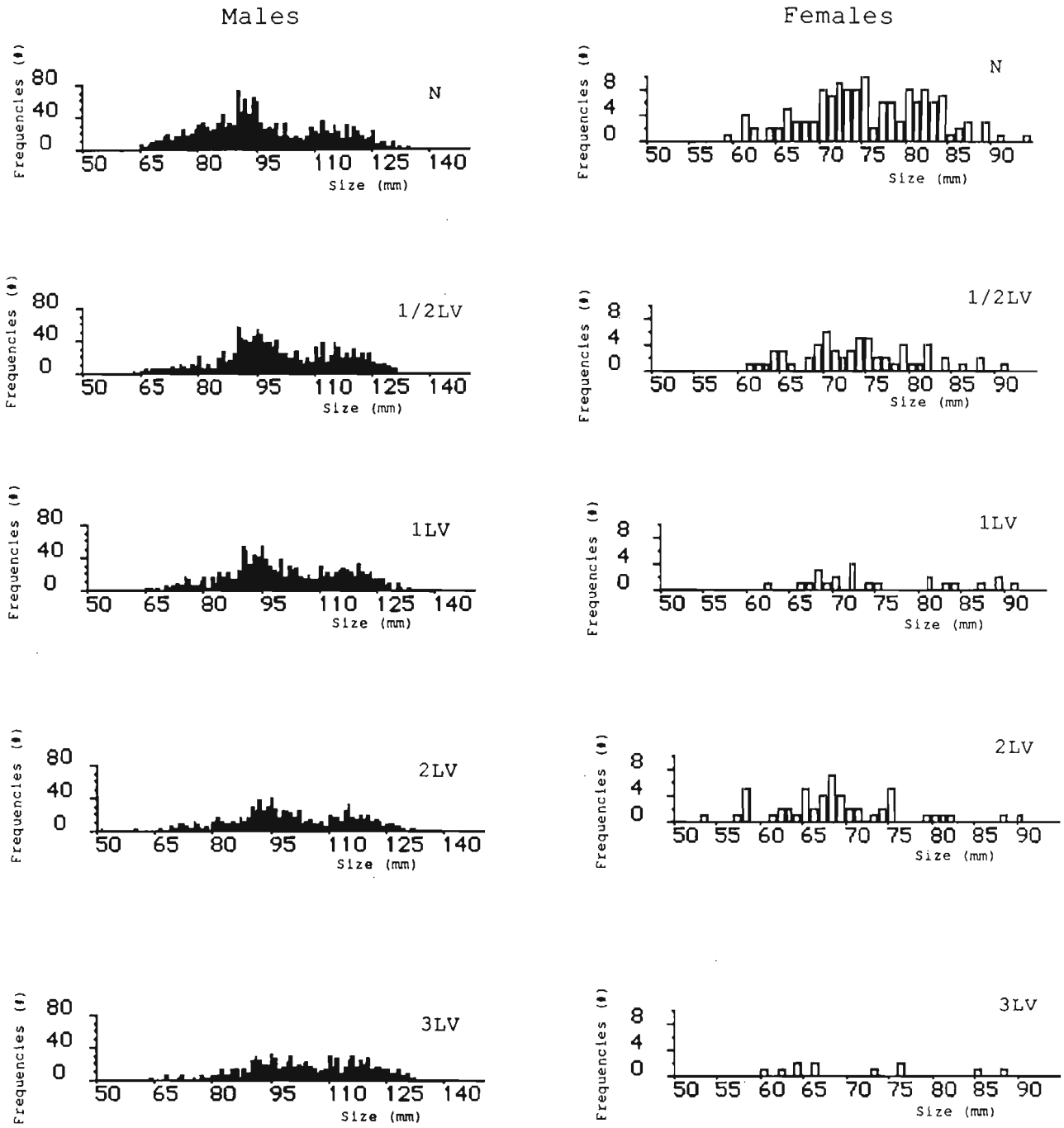


Figure 6. Size distribution of male and female crab collected from different trap types.

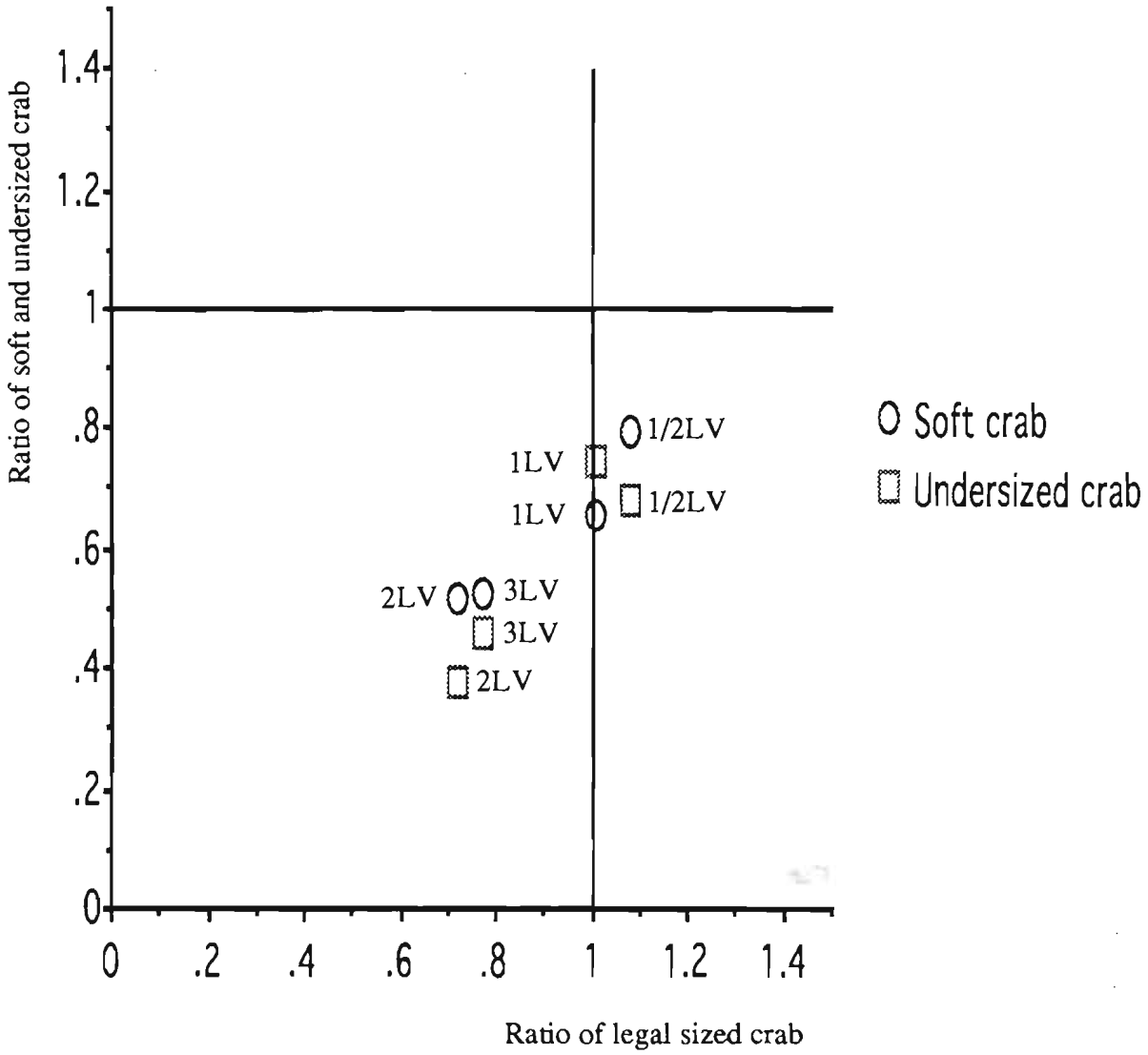


Figure 7. Ratio of CPUE of modified traps (in mean number of crab per trap) to the CPUE of a normal trap.

Appendix 1. Values of t and p (with 51 degrees of freedom) from the CPUE comparison done by ANOVA.

Comparison	CPUE in number						CPUE in weight	
	Soft		hard ≥95 mm		hard <95 mm		≥ 95 mm	
	t	p	t	p	t	p	t	p
N vs 1/2LV	1.18	.2819	0.21	.6458	3.54	.0658	0.13	.7240
N vs 1LV	4.32	.0429	0.01	.9401	3.11	.0837	9E-5	.9923
N vs 2LV	8.85	.0045	3.33	.0738	15.95	.0002	3.37	.0725
N vs 3LV	7.84	.0073	2.58	.1144	23.07	.0001	2.19	.1448
1/2LV vs 1LV	1.07	.3067	0.20	.6542	0.17	.6809	0.17	.6835
1/2LV vs 2LV	4.56	.0377	5.72	.0206	2.99	.0899	5.67	.0214
1/2LV vs 3LV	3.76	.058	4.92	.0312	6.00	.0178	4.20	.0457
1LV vs 2LV	2.22	.1423	5.06	.0289	7.82	.0073	5.20	.0269
1LV vs 3LV	1.56	.2175	4.28	.0439	15.27	.0003	3.68	.0606
2LV vs 3LV	0.01	.9326	0.20	.6606	0.99	.3251	0.37	.5433

N=Normal (conventional) trap
LV=modified trap with panel on the vertical slope

Appendix 2. Values of t, p and degrees of freedom (df) from the t-test on mean size.

Comparison	Total			≥95 mm			<95 mm		
	t	p	df	t	p	df	t	p	df
N vs 1/2LV	6.81	.0001	2966	-0.88	.3782	1691	3.08	.0021	1273
N vs 1LV	-6.84	.0001	2884	0.34	.7333	1622	-4.31	.0001	1260
N vs 2LV	4.42	.0001	2517	-1.27	.2035	1373	2.05	.0403	1142
N vs 3LV	11.45	.0001	2511	1.88	.0605	1472	4.73	.0001	1037
1/2LV vs 1LV	-0.11	.9093	2632	-.54	.5905	1689	-1.05	.2950	941
1/2LV vs 2LV	-1.58	.1144	2265	-.50	.6185	1440	-.61	.5440	823
1/2LV vs 3LV	5.42	.0001	2259	2.76	.0059	1539	2.07	.0391	718
1LV vs 2LV	-1.67	.0946	2183	-.97	.3314	1371	-1.57	.1165	810
1LV vs 3LV	5.29	.0001	2177	2.22	.0267	1470	1.26	.2088	705
2LV vs 3LV	-6.41	.0001	1810	2.96	.0031	1221	-2.43	.0154	587

N=Normal (conventional trap)
LV=modified trap with panel on the vertical slope

Appendix 3. Values of D and p from Kolmogorov-Smirnov test on size structure.

Comparison	males		females	
	D	p	D	p
Normal vs 1/2LV	0.14	.0001	0.14	.3514
Normal vs 1LV	0.13	.0004	0.22	.3388
Normal vs 2LV	0.12	.0043	0.48	.0028
Normal vs 3LV	0.23	.0001	0.43	.1685
1/2LV vs 1LV	0.01	.7012	0.17	.4852
1/2LV vs 2LV	0.03	.4180	0.39	.0390
1/2LV vs 3LV	0.11	.0084	0.38	.2403
1LV vs 2LV	0.04	.3961	0.36	.1539
1LV vs 3LV	0.11	.0114	0.46	.2110
2LV vs 3LV	0.14	.0028	0.25	.4497

Normal=conventional trap
LV=modified trap with panel on the vertical slope