A bait comparison study in the Newfoundland and Labrador snow crab (*Chionoecetes opilio*) fishery: does Atlantic herring stand a chance against squid?

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*Submitted to:*

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P.O. Box 8700, St. John’s, NL,
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Table of Contents

Executive Summary .................................................................................................................. 1
Introduction ............................................................................................................................... 2
Materials and Methods ........................................................................................................... 3
Results ..................................................................................................................................... 7
Discussion ............................................................................................................................... 13
Acknowledgements ............................................................................................................... 18
Literature cited ......................................................................................................................... 18
Tables .................................................................................................................................... 20
Figures ................................................................................................................................... 35

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EXECUTIVE SUMMARY

Squid is the preferred bait in the Newfoundland and Labrador snow crab trap fishery. The variable rising costs of squid have at times caused fishermen to supplement squid with Atlantic herring which is a less expensive option however, the economic benefits are unclear. The current study compared the catches of snow crab in four bait configurations (treatments) of squid and/or herring. One bait configuration was the quantity of squid typically used to bait a trap (2 lbs, 0.9 kg), two of the bait configurations comprised herring as an equal quantity (2 lbs herring) or equal monetary value (5 lbs/2.3 kg herring) of 2 lbs squid, and the fourth bait configuration was a 2 lb 1:1 ratio of squid and herring. Catch rates of the four bait configurations were assessed under simulated commercial conditions by using a separate fleet of 20 traps for each bait configuration (i.e., four ‘commercial’ fleets) and through the use of a ‘science’ fleet, which was comprised of five replicates of each of the four bait configurations. The study was carried out on snow crab fishing grounds in Conception Bay from 4-21 July 2009 where 15 hauls were conducted with each of the five fleets (four commercial and one science) for a total of 75 hauls.

This study demonstrated the importance of squid as bait in the snow crab trap fishery, the importance of the quantity of bait when herring is used alone, and suggested a slight advantage in catch rates with a bait combination of herring and squid in commercial fleets. The 2 lb 1:1 ratio of squid and herring and 2 lbs squid performed best overall in both the science and commercial fleets exhibiting a total catch of legal size hard-shell crab over 15 hauls of each bait configuration that were 8.3-13% higher than 5 lbs herring and 21-33% higher than 2 lbs herring. In the commercial fleets, the 2 lb 1:1 ratio of squid and herring and 2 lbs squid were the only bait configurations to have significantly higher catch rates than all other bait configurations, which they did in 33% of the comparisons. Commercial fleets baited with a 2 lb 1:1 ratio of squid and herring significantly outperformed 2 lbs squid in 20% of the comparisons while 2 lbs squid significantly outperformed 2 lbs 1:1 ratio of squid and herring in 13% of the comparisons. When averaged over three weeks of fishing, the mean percent contribution of sublegal males and legal size soft-shell crab to the total catch (kg) did not differ significantly between bait configurations.

Overall, this study demonstrated that commercial fleets baited with a 2 lb 1:1 ratio of squid and herring performed marginally (4.3% higher catch) better than fleets baited with 2 lbs squid and given the lower price for herring provide compelling evidence to promote the use of both bait types. The 2007 snow crab stock assessment indicated the total trap effort in the Newfoundland and Labrador snow crab fishery (i.e., NAFO 2J3KLNOP4R) was 4.59 million traps. A simple cost benefit analysis based on bait costs in 2009 and a substitution of 2 lbs squid with a 2 lb 1:1 ratio of squid and herring throughout the fishery suggested there could have been a savings in the order of $1.8 million to the harvesting sector of the snow crab industry in 2007. Although herring alone may not stand a chance against squid, bait that combines an equal quantity of herring and squid has the potential to provide significant savings to the harvesting sector without negatively impacting the catch of legal size hard-shell crab.
INTRODUCTION

Investigations comparing the performance of different baits in static fishing gear are a daunting task. Several factors may affect the target species behaviour toward a specific bait plume such as; intrinsic sensory limitations related to sex, condition, and stage of the life cycle, temperature and metabolic processes, current direction and velocity, turbidity and light levels, prey availability and levels of satiation. Further, several factors can influence catch rates in baited traps other than a change in bait type or quantity of bait. For example, differences in abundance of the targeted species within the effective trap area of an individual trap or fleet of traps may influence catch rates. Factors influencing local abundance include substrate type, depth, temperature, food availability, and previous levels of fishing pressure. Complex interactions of fish with baited fishing gears have been reviewed by Stoner (2004) and research comparing capture rates of different baits in trap fisheries is sparse (Walsh 2001, Dale et al. 2007, Archdale et al. 2008).

The purpose of this study was to determine whether Atlantic herring (*Clupea harengus*), a less commonly used bait in the Newfoundland and Labrador region, can be as effective at attracting and capturing snow crab (*Chionoecetes opilio*) as squid, the more commonly used bait. The squid used as bait in the regions snow crab fishery is not only imported and food grade, but also substantially more expensive then Atlantic herring which is captured locally from five resident stocks. Anecdotal information from the Newfoundland and Labrador region suggests that herring is not as effective as squid at attracting snow crab. Nevertheless, some fishermen use herring alone or in combination with squid and/or mackerel and there are times when herring appears to perform close to or as well as squid so from an economic standpoint a greater use of herring may hold some merit for the region. Herring and mackerel are commonly used in the snow crab fishery in the Gulf of St. Lawrence where larger conical traps (2.1 m vs. 1.2 m) are utilized and large quantities (e.g., up to 13 kg) of herring and/or mackerel are used to bait individual traps.
The price of herring and squid can vary from year-to-year and within a fishing season. When this study was initiated in early July of 2009 squid was 2.5× the cost of herring ($0.65/lb vs. $0.26/lb). Fishing enterprises need to optimize their fishing operations in order to make them as profitable as possible particularly in years when the price of snow crab is low (e.g., $1.40/lb in 2009) and a reduction in the cost of bait is one way to improve upon the bottom line. Large quantities of herring are being captured locally, however the potential economic benefits of using herring as bait in the snow crab fishery have not been previously studied. In the current study, capture rates of snow crab were compared on snow crab fishing grounds in Conception Bay in July by utilizing four bait configurations of squid and/or herring. The bait configurations tested were compared among four commercial fleets, in which all traps in a fleet were baited equally, and from a science fleet in which all bait configurations were randomly represented.

**MATERIALS AND METHODS**

The traditional conical snow crab trap utilized in the Newfoundland and Labrador fishery was used in this study (i.e., 1.2 m bottom diameter). All traps were fitted with 140 mm (5 ½") stretched mesh and a single top mounted plastic entrance cone (Fig. 1). All traps were fished with large (38 cm × 30.5 cm; 15" × 12") polyethylene bait protection bags (Fig. 2) which were hung from the centre of the trap by attachment to the entrance cone. Bait protection bags reduce scavenging by sea lice (amphipods). Use of bait protection is a common practice during the execution of this fishery. Herring bait requires the use of bait protection due to its soft nature and inability to stay on skivers while squid bait is often hung freely on skivers but may also be placed in bait protection devices (mesh bags or perforated tubs). To this end it was decided that all bait used in this study would be placed in protective bags to maintain consistency among the bait configurations tested. The herring bait used in this study was captured locally in the current year and fast frozen to maintain freshness. The squid bait was imported from the United States but was also captured and fast frozen in the current year. Bait was partially thawed on a daily basis to allow separation from frozen 10-20 kg blocks prior to being placed in the bait bags.
Four bait treatments (bait configurations) of squid and/or herring were used to compare the catch rates of snow crab. Treatment I was the quantity of squid typically used to bait a trap. Treatments II and III comprised herring as quantitative and monetary variants of Treatment I and Treatment IV was a combination of squid and herring. When squid is the only bait used, fishermen typically use six squid to bait a trap (Alex Day, High Tide Enterprises, pers. comm.). It was discovered from several replicate weight (± 10 g) measurements that six squid weigh an average of 0.9 kg (2 lbs). The first variant of Treatment I was an equal weight of herring (0.9 kg) which was found to consist of three fish. The second variant was a quantity of herring that was approximately the monetary value of 0.9 kg of squid. The price of herring and squid can vary from year-to-year and within a fishing season. When this study was initiated squid was 2.5× the cost of herring ($0.65/lb vs. $0.26/lb) therefore Treatment III consisted of approximately 2.3 kg (5 lb) of herring which was found to consist of seven fish. The final variant was an approximation of a 1:1 ratio of squid and herring to a weight of approximately 0.9 kg which consisted of two herring and three squid. Overall the four bait treatments may be summarized as follows:

- **Treatment I:** 2 lbs squid (0.9 kg),
- **Treatment II:** 2 lbs herring,
- **Treatment III:** 5 lbs herring (2.3 kg), and
- **Treatment IV:** 2 lbs 1:1 squid:herring.

Catch rates of the four bait treatments/configurations were assessed under simulated commercial conditions by using a separate fleet of 20 traps for each bait treatment (i.e., four ‘commercial’ fleets). Several factors can influence catch rates in baited traps other than a change in bait configuration or quantity of bait. For example, differences in abundance of snow crab within the effective trap area of an individual trap or a fleet of traps may influence catch rates. A fleet of traps baited with herring may perform better than a fleet of traps baited with squid simply because there was a greater abundance of snow crab in the effective trap area of the fleet of herring traps. However, acceptable trends in relative capture performance among bait treatments may be expected when a large and comparable number of sets are carried out with each bait treatment, particularly when they are carried out on the same fishing grounds.
One way to deal with local differences in abundance of snow crab and its effect on catch rates is to randomly distribute replicates of each bait treatment within a fleet of traps. In the current study a fifth fleet, here referred to as the ‘science’ fleet, was used to test for differences in the catch rates among the four bait treatments. Five replicates of each of the four bait treatments were randomly distributed among 20 traps in the science fleet. Once the random distribution of bait treatments was determined for the science fleet it was not changed throughout the course of the study.

Studies in the Newfoundland and Labrador region suggest the effective fishing radius of a snow crab trap is approximately 37 m (20 ftm; E. Dawe, DFO, pers. comm.). In the current study, the distance between traps within a fleet was set at 55 m (30 ftm) in an effort to remove the bait influence from one trap to another. Further, this is the trap spacing commonly used in the regions snow crab fishery. All traps in the commercial and science fleets were baited daily with fresh squid and/or herring. Bait removed from the traps was held on board the vessel until the end of the days fishing and discarded 4-5 km from the fishing grounds.

This study was conducted on snow crab fishing grounds in Conception Bay (Fig. 3 and 4) from 4-21 July 2009. Five fishing areas (FA) were arbitrarily selected on Day 1. The fishing areas were separated by approximately 1.8 km (1 nm). The five fleets (four commercial and one science) were randomly set among the five FA’s so that each fleet fished on one of the FA’s on Day 1. The five fleets were rotated among the five FA’s on a daily basis so that each FA was subjected to all five fleets and hence all four bait treatments over a five-day rotation. During each five-day rotation the fleets were set in a north to south orientation (Fig. 3 and 4). This five-day rotation of fleets was to be repeated three times among the initial five FA’s for a total of 15 fishing days for each of the five fleets and three sets per FA for each treatment/fleet. However, after five days of fishing three of the FA’s were moved due to high catch rates of soft-shell crab. Specifically, FA’s 3, 4, and 5 (Fig. 3) were moved to FA’s 6, 7, and 8, respectively, for the two remaining five-day rotations (Fig. 4). Soak times were approximately 24 hours in duration except on one occasion during the second rotation when all five fleets experienced a soak time of
approximately 72 hours. Hereafter, the three five-day fleet rotations will be referred to as weeks 1, 2, and 3 and the four bait treatments will be referred to as bait configurations.

The current fishing plan, which consisted of rotating the five fleets among closely spaced FA’s, was modelled after typical fishing practices. When fishing within a relatively limited FA, fishermen may redeploy a fleet end over end or to the left or right of the previous deployment. Apart from a single fleet rotation on Day 2 of Week 1, when the fleets were moved end over end of the previous deployment within a FA (Figure 3), all remaining fleet rotations were deployed approximately 100 m to the east of the previous deployment within a given FA (Figure 3 and 4).

The research platform used during this study was the 19.2 m (63’) CFV Island Voyager. Although the snow crab fishery is prosecuted by smaller vessels (<40’) on the fishing grounds utilized during this study, a larger research platform (vessel) was deemed necessary to provide adequate space for data collection and to limit downtime due to inclement weather. One of two representatives of the Conception Bay Under 40’ Crab Committee accompanied the research team throughout the study.

Bottom temperature was recorded daily at two locations within the study area by attaching a temperature data logger (VEMCO®) to one of the traps within a fleet. Operational temperature range of the data loggers was -4.0 to 20.0 °C, resolution was 0.1 to 0.2 °C, and accuracy was ±0.1 to ±0.2 °C. All temperature data loggers used in this study are calibrated annually for accuracy. Bottom depth at each set location was recorded using the fishing vessel’s echosounder.

Individual trap catches of snow crab were assessed for four categories: 1) legal size hard-shell males (≥ 95 mm carapace width); 2) legal size soft-shell males; 3) sublegal size males; and 4) females. The count and total weight (±10 g) per trap was recorded for each snow crab category. All snow crab captured during this study were immediately returned to the ocean within the FA of capture. Incidental bycatch was identified to genera and counted for each fleet of traps. Snow crab catch per unit effort (CPUE; kg/trap) and percent contribution of legal sized soft-shell and sublegal size males were compared using analysis of variance (ANOVA). Proportional data were arcsine square root transformed and CPUE data were log_{10}(n+1) transformed to improve
normality and equality of variances. Statistical procedures were conducted using SPSS® 17.0.7 (SPSS 2008).

RESULTS

During approximately three weeks of fishing (4-21 July) a total of 75 fleets (20 traps/fleet) were successfully set and hauled (i.e., 60 commercial type fleets and 15 science fleets). The majority (93%) of the fleets were left to fish overnight with soak times ranging from 21.5 to 26.5 hr (mean, 23.3 hr). During the second week of the study, five fleets (i.e., four commercial and one science) fished for three nights with soak times ranging from 71.5 to 72.0 hr (mean, 71.9 hr). Within the study area depths fished ranged from 145 to 195 m (mean, 168 m) (79 to 107 ftm; mean, 91.9 ftm) (Table 1). Bottom temperatures were subzero throughout the course of the study ranging from -1.5°C to -1.2°C.

Trap saturation was not observed during haul-back reducing the likelihood of escapement of large crab through the entrance cone and selectivity of smaller crab. Bait quality was high for both herring and squid after an overnight set which may be attributed to the subzero bottom water temperatures on the fishing grounds. Fishermen participating in the study indicated that the quality was sufficient to merit reuse in the commercial fishery. Nevertheless, as was outlined above, in the current study all traps were baited with fresh bait daily.

Percent contribution of legal size soft-shell snow crab to the total catch weight in all bait configurations combined ranged from 1% in FA’s 6 and 8 to 79% in FA 5 (Table 1). Legal size soft-shell crab dominated the catches (>50%) at FA’s 3, 4, and 5 during the first week of the study (Table 1) which led to a shift in fishing effort to FA’s 6, 7, and 8 for the remainder of the study (Fig. 3 and 4). Fishermen participating in the study commented on the high activity levels and overall good condition of the soft-shell snow crab as they were returned to the ocean which may be attributed to the quick and gentle handling practices. Percent contribution of sublegal size male crab to the total catch weight in all bait configurations combined was highly variable between FA’s ranging from 11% at FA 5 to 57% at FA 1 (Table 1). Lowest percent contributions of sublegal size male crab to the total catch were observed at FA’s 3, 4, and 5 and
these fishing areas also exhibited the highest percent contribution of legal size soft-shell crab. Several of the sublegal size males captured at FA’s 3, 4, and 5 may have also been in the soft-shell state, however shell condition was not assessed for this crab category. Female snow crab were not captured at FA’s 3 and 5 and exhibited the highest percent contribution to the total catch weight at FA’s 1 and 8 (Table 1). Fishing areas 1 and 8 also exhibited the highest percentage of sublegal size male crab (Table 1).

Incidental bycatch was limited to two genera; *Buccinum* sp. (whelks) and *Hyas* sp. (toad crabs). Benthic species assemblages can provide valuable indicators of the substrate type within a fishing area. In Conception Bay, toad crab are most commonly encountered in shallower waters (20-50 m) than snow crab and appear to prefer gravel and cobble/pebble substrates but may also be captured on sand and mud bottom (Miller and O’Keefe 1981). Highest catches of toad crab occurred within FA’s 1 and 2 and to a lesser extent FA’s 6 and 8 and these four FA’s also exhibited the highest percent contribution of sublegal size snow crab and females (Table 1) suggesting a mixed bottom type of hard and soft substrates in these fishing areas. Mud was commonly observed on traps hauled at fishing areas 3, 4, and 5 and soft-shell crabs commonly seek bottom areas with a deep overburden of mud to burrow within for protection from predators.

Mean capture rates of legal size hard-shell snow crab varied considerably between FA’s (Fig. 5 and 6) with FA 5 exhibiting the lowest catch rates (i.e., <2 kg/trap) independent of bait configuration and fleet type (commercial/science), while FA 7 exhibited the highest catch rates (i.e., 6-7.6 kg/trap) again, independent of bait configuration and fleet type. Mean capture rates of legal size hard-shell crab within FA 7 were well below the annual commercial capture rates (i.e., CPUE) in the offshore region of Division 3L and marginally lower than the 2004 inshore capture rates (Table 2). In the current study, catch rates within a FA did not show evidence of depletion fishing (Fig. 7).

Two-way ANOVAs were performed on the snow crab catch data for the categories legal size hard-shell and sublegal size male to determine whether the catch data within a bait configuration could be pooled across FA’s or weeks. Significance of the interaction term in two-way
ANOVAs performed on the commercial fleet catch data (Table 3 and 4) precluded an interpretation of the main effects of FA and week on mean CPUE and subsequently one-way ANOVAs were performed upon each of the main effects (Table 5 and 6). Overall, analyses of the commercial fleet catch data indicated there were within bait configuration differences in mean CPUE of snow crab between weeks (Table 5) and FA’s (Table 6) for both legal size hard-shell and sublegal size male crab. Subsequently, analyses of between bait configuration differences in mean CPUE of each crab category from the commercial fleets had to be performed separately for each week and each FA (Table 7).

When it came to the within bait configuration analyses of the effect of FA and week on the mean CPUE in the science fleet the interaction term of the two-way ANOVA’s was significant in a single comparison, the legal size hard-shell category for traps baited with 5 lbs herring (Table 8 and 9). For each of the three remaining bait configurations two-way ANOVA’s indicated catch rates of legal size hard-shell crab differed significantly between FA’s but did not differ significantly between weeks (Table 8). One-way ANOVA’s to test the effect of FA on catch rates in traps baited with 5 lbs herring indicated the mean CPUE of legal size hard-shell crab differed significantly between FA’s in Week 1 ($F_{4,20} = 3.602$, $p=0.023$), Week 2 ($F_{4,20} = 6.591$, $p=0.001$), and Week 3 ($F_{4,20} = 8.533$, $p<0.001$). One-way ANOVA’s to test the effect of week on catch rates in traps baited with 5 lbs herring indicated the mean CPUE of legal size hard-shell crab differed significantly between weeks in FA 2 ($F_{2,12} = 4.036$, $p=0.046$) and FA 8 ($F_{2,12} = 6.104$, $p=0.039$), but did not differ significantly between weeks in FA 1 ($F_{1,8} = 2.489$, $p=0.125$), FA 6 ($F_{1,8} = 1.435$, $p=0.265$), and FA 7 ($F_{1,8} = 0.001$, $p=0.989$). Overall, these analyses indicated that an analysis of between bait configuration differences in mean CPUE of legal size hard-shell crab had to be performed separately for each FA but the catch data could be pooled across weeks in FA’s 1, 6, and 7 (Table 10).

Two-way ANOVA’s performed on catch rates of the sublegal male category in the science fleet indicated the mean CPUE within each bait configuration did not differ significantly between weeks but did differ significantly between FA’s (Table 9). Subsequently, the science fleet catch data were pooled by week for the sublegal male category and between bait configuration differences in mean CPUE were analysed separately for each FA (Table 10).
One-way analyses of variance indicated significant between bait configuration differences in mean CPUE for each snow crab category captured in the commercial fleets (Table 7) but mean CPUE did not differ significantly between bait configuration for any of the snow crab categories in the science fleet (Table 10). Nevertheless, examination of the homogeneous subsets (Fig. 8-10) indicated commercial fleets baited with 2 lbs of squid or a 2 lb 1:1 squid:herring combination exhibit significantly higher catch rates of legal size hard-shell snow crab in five (33%) of the 15 comparisons while commercial fleets baited with 2 lbs herring were found to exhibit significantly lower catch rates than all other bait configurations in four (27%) of the 15 comparisons.

Examination of the homogeneous subsets for the catch rates of legal size hard-shell crab (Fig. 8-10) indicated commercial fleets baited with the 2 lb 1:1 squid:herring combination significantly outperformed all other bait configurations in three of the 15 comparisons, significantly outperformed 2 lbs squid in an additional two comparisons, and overall performed as well as or better than 2 lbs squid in 11 (73%) of the comparisons. Two pounds squid significantly outperformed all other bait configurations in two comparisons, significantly outperformed the 2 lbs 1:1 squid:herring combination in two comparisons, and performed as well as or better than 2 lb 1:1 squid:herring in 10 (67%) of the comparisons. Commercial fleets baited with 5 lbs herring did not significantly out perform all other bait configurations in any of the comparisons but did significantly out perform 2 lbs 1:1 squid:herring in two (13%) of the comparisons and performed as well as 2 lbs 1:1 squid:herring in an additional seven (47%) of the comparisons. Commercial fleets baited with 5 lbs herring performed as well as 2 lbs squid in 11 (73%) of the comparisons. Commercial fleets baited with 5 lbs of herring significantly outperformed fleets baited with 2 lbs of herring in seven (47%) of the comparisons while 2 lbs herring significantly outperformed 5 lbs herring in only one (7%) of the comparisons. Commercial fleets baited with 2 lbs herring performed as well as or significantly better than squid in five (33%) of the bait comparisons while 2 lbs herring performed only as well as 1:1 squid:herring in eight (53%) of the comparisons.
Overall, results from the commercial fleets demonstrate the importance of squid as bait, the importance of the quantity of bait when herring is used alone, and suggest a slight advantage in catch rates with an equal bait combination of herring and squid. This is further demonstrated by analysis of the total catch in the commercial fleets over the entire study (Fig. 11 and 12; Table 1). Commercial fleets baited with the 1:1 squid:herring combination performed best on a weekly basis (Fig. 11; Table 11) and when the catches were summed over three weeks (Fig. 12; Table 11) the 1:1 squid:herring combination captured 4.3% more legal size hard-shell snow crab than squid alone, 13% more than 5 lbs herring, and 33% more than 2 lbs herring.

Although mean catch rates of snow crab in the science fleet did not differ significantly between bait configurations (Table 10) and mean catch rates of each bait configuration exhibited dissimilar trends when compared to the commercial fleets in the same FA’s (Fig. 8-10) the total catch for each bait configuration did show the same general trends as the total catch in the commercial fleets, particularly when summed over three weeks (Fig. 12 and 13; Table 12). As in the commercial fleets, traps baited entirely or partially with squid performed best overall in the science fleet and higher quantities of herring resulted in a higher total catch (Fig. 12), however the rank order of 2 lbs squid and the 2 lb 1:1 squid:herring combination was reversed in the science fleet. Overall, when the catches in the science fleet were summed over three weeks 2 lbs squid captured 5.2% more legal size hard-shell crab than the 2 lb 1:1 squid:herring combination, 8.3% more than 5 lbs herring, and 21% more than 2 lbs herring (Fig. 12; Table 12).

Legal size soft-shell snow crab dominated the catches in FA’s 3, 4, and 5 and comprised 15% of the total catch (kg) in FA 2 (Table 1). In the commercial fleets, catch rates of legal size soft-shell crab differed significantly between bait configurations at FA 2 and 4 during Week 1 (Table 7), however the homogenous subsets differed between FA’s (Fig. 14). Low catches of soft-shell crab during weeks 2 and 3 precluded an analysis of the influence of bait configuration on catch rates of this snow crab category. In the science fleet, catch rates of legal size soft-shell crab did not differ significantly between bait configurations during Week 1 (Table 10; Fig. 14). Ultimately, the results are unclear with regard to any reduction in catch rates of legal size soft-shell crab with bait treatment.
A more meaningful analysis of the influence of bait configuration on the catch of soft-shell crab would be a comparison of the percent contribution of soft-shell crab to the total catch as persistently high percentages of soft-shell crab can close a fishing area for the season. Two-way analyses of variance indicated the percent contribution of legal size soft-shell crab to the total catch (kg) did not differ significantly between bait configurations within or between fleet types (commercial vs. science) during Week 1 when soft-shell crab dominated the catches at three of the five fishing areas or over all three weeks combined (Table 13; Fig. 15 and 16).

Mean percent contribution of sublegal size male snow crab to the total catch (kg) was highly variable among fishing areas but exhibited relatively little variability among bait configurations (Fig. 17). Mean percent contribution of sublegal males also exhibited low variability among bait configurations when summed across fishing areas (Fig. 18 and 19). Two-way analyses of variance indicated the percent contribution of sublegal size males to the total catch (kg) did not differ significantly between bait configurations within or between fleet types (commercial vs. science) during Week 1 and 3 or over all three weeks combined (Table 14). During Week 2, the percent contribution of sublegal size males did not differ between fleet types but did differ between bait configurations (Table 14). Post-hoc analyses of the Week 2 data indicated the 2 lb 1:1 squid:herring combination captured a significantly lower proportion of sublegal males than 2 lbs herring while 2 lbs squid and 5 lbs herring exhibited proportions that were medial to and did not differ significantly from either the 2 lb 1:1 squid:herring bait combination or 2 lbs herring.

Mean catch rates of sublegal size males in commercial fleets differed significantly between bait configurations in 11 of the 15 within FA comparisons (Table 7; Fig. 20-22). For 10 of these 11 comparisons catch rates of legal size hard-shell crab also exhibited significant differences between bait configurations (Table 7), however the homogeneous subsets differed among the two crab categories (Fig. 8-10 and 20-22). Nevertheless, nine of the 11 comparisons (82%) that exhibited significant differences in mean catch rates between bait configurations showed similar trends in mean catch rates among bait configurations for both the legal size hard-shell crab and sublegal size male crab. Although mean catch rates of sublegal size males did not differ significantly between bait configurations in the science fleet, mean catch rates of legal size hard-shell crab and sublegal size males exhibited similar trends among bait configurations in seven of
the 15 comparisons (i.e., 47%; Fig. 8-10 and 20-22). Overall, these results suggest the attractive properties of each bait configuration act similarly on legal size hard-shell and sublegal size males.

Discussion

This study demonstrates the importance of squid as bait in the snow crab trap fishery, the importance of the quantity of bait when herring is used alone, and suggests a slight advantage in catch rates with a bait combination of herring and squid in commercial fleets. The 2 lb 1:1 squid:herring combination and 2 lbs squid bait configurations performed best overall in both the science and commercial fleets exhibiting a total catch over 15 hauls of each bait configuration that were 8.3-13% higher than 5 lbs herring and 21-33% higher than 2 lbs herring. In the commercial fleets, the 2 lb 1:1 squid:herring combination and 2 lbs squid were the only bait configurations to significantly outperform (i.e., significantly higher catch rates) all other bait configurations, which they did in 33% of the comparisons. Commercial fleets baited with the 2 lb 1:1 squid:herring combination significantly outperformed 2 lbs squid in 20% of the comparisons while 2 lbs squid significantly outperformed the 2 lb 1:1 squid:herring combination in 13% of the comparisons.

Fishermen frequently comment on the high variability in catch rates of snow crab even when the commonly preferred bait configuration (i.e., squid alone) is used. For example, a fleet of traps set on grounds where a previous haul performed poorly may provide acceptable or even higher than usual catch rates for the year during the following haul. Food availability and levels of satiation among crab in a localized area can influence catch rates and fishermen frequently comment on the dismal catches of snow crab that occur when bait-fish (e.g., capelin) are in the area. Depth and substrate type is known to influence capture rates of legal size, sublegal size, and soft-shell snow crab and seemingly minor differences in temperature also appear to dramatically influence catch rates (Andrew Daley, pers. comm.). High capture rates of sublegal size snow crab are often associated with relatively shallow water areas with mixed (soft and hard) substrate types while soft-shell crab are often associated with a deep and variable
overburden of soft substrate which is frequently evident on traps when they are hauled. In many circumstances, the percent contribution of sublegal size or soft-shell crab can be reduced by moving fishing gear seemingly minor distances where apparently differences in habitat type (substrate, depth, temperature, current velocity, etc) reduce the catch rates (i.e., presence) of these unwanted size/shell condition categories of snow crab. Accepting the fact that appreciable variability in catch rates of snow crab with the same preferred bait can be achieved by moving fishing gear seemingly minor distances or even on what appears to be the same fishing ground (i.e., same latitude and longitude) makes investigations comparing the performance of different baits a daunting task. The current study attempted to deal with this variability by conducting several (15) between bait comparisons with both commercial and science fleets in hopes that at the very least, a common trend would emerge. Fortunately, a common trend did emerge with fleets (commercial) and traps (science) baited partially or entirely with squid performing best with regard to the capture of legal size hard-shell snow crab over 15 hauls of each bait configuration. Given the high number of hauls carried out in this study it is unlikely that additional hauls would change the overall trend in catches observed between bait configurations.

Generally, catch rates (i.e., kg/trap) in the commercial and science fleets were well below the annual averages for the NAFO Division where the study took place (3L) which is attributed to the previous fishing pressure and stage of the moult cycle of snow crab. This study was conducted late in the fishing season when most of the inshore quota for Division 3L was captured and when soft-shell begin to dominate the catches, hence fewer legal size hard-shell crab were expected. At this time, there is no reason to suspect that the overall trends in the relative performance of the bait configurations in commercial and science fleets would change appreciably during the height of the fishing season.

In the current study, catch rates of all three categories of male snow crab (legal size hard-shell, legal size soft-shell, and sublegal size male) differed significantly between bait configurations in the commercial fleets, while in the science fleet catch rates did not differ significantly between bait configurations. One possible explanation for this may have to do with effective fishing area of a baited trap. The four commercial fleets each comprised only one of the four bait treatments while traps in the science fleet were one of four different bait treatments, randomly distributed
within the fleet, and placed 55 m (30 ftm) apart. It is possible that the distance between traps within the science fleet may not have been great enough to alleviate bait influence from one trap to the next, thus accounting for non-significant differences in catch rates between traps. Studies in the Gulf of St. Lawrence suggest the effective fishing radius of a snow crab trap may be as great as 70 m when baited with 2 kg (4.4 lb) of Atlantic herring or cod (*Gadus morhua*) (Brêthes et al. 1985) and traps were baited with 2.3 kg of herring in the current study. Although it seems intuitive, it is unclear how or even if the effective fishing radius of a trap set for snow crab is affected by the quantity or type of bait.

Another possible explanation for non-significant differences in catch rates between bait configurations in the science fleet is the number of trap comparisons within each bait configuration which was small (n = 5) for the ANOVA’s performed and can lead to a relatively high error component in the analysis which may preclude significant differences in catch rates. Increasing (i.e., doubling) the number of replicates of each bait configuration in a science fleet would help to alleviate this problem. However, an increase in the length of a fleet increases the chance of sampling from different habitat types which by their intrinsic features support different quantities of the snow crab categories examined such that significant differences in catch rates may be due to differing numbers of crab within the effective trap radius rather than differences due to bait configuration.

Results of this study, demonstrated that commercial fleets baited with a 2 lb 1:1 squid:herring combination performed marginally better than commercial fleets baited with 2 lbs squid and given the lower price for herring provide compelling evidence to promote the use of both bait types in the Newfoundland and Labrador trap fishery. A previous study indicated the quantity of squid alone can affect the capture rates of snow crab (Miller 1983), therefore greater overall performance observed in this study with a reduction in squid in the 2 lb 1:1 squid:herring combination is attributed to the combined attractant qualities of both bait types. When this study was carried out the price of herring was $0.26/lb and squid was $0.65/lb. Therefore the cost to bait a trap with a 2 lb 1:1 squid:herring combination was approximately $0.91 compared to $1.30 for a trap baited with 2 lbs squid such that traps baited with a 2 lb 1:1 squid:herring combination result in savings of $0.39 per trap. Snow crab trap effort in NAFO Division 3L over the past 13
years was summarized by Dawe et al. (2009) and is presented herein in Table 15. To facilitate a cost benefit analysis, we assumed that all traps in 3L were baited with 2 lbs of squid over the past 13 years and the present cost savings of $0.39/trap when 2 lbs of squid was substituted with the 2 lb 1:1 squid:herring combination. The assumption that all traps are baited with squid alone is likely to be more applicable to the offshore sector. This cost benefit analysis indicates average savings of approximately $240,000 in the inshore sector and $419,000 in the offshore sector for a total average savings of $659,000 for Division 3L over 13 years. This is a simplified cost benefit analysis for a number of reasons, one of which is the price of herring and squid which varies within and between years however, herring has always been the less expensive bait of the two so this analysis holds some merit.

Expanding this cost benefit analysis to all NAFO Divisions for the Newfoundland and Labrador region (NAFO 2J3KLNOPsPn4R) for 2007 when a total of 4.59 million traps were set (Dawe et al. 2009) would amount to a savings of $1.8 million to the harvesting sector of the snow crab industry. This would require 4.59 million lbs or 2,080 metric tons (t) of herring. According to the latest Science Advisory Report on the status of Newfoundland herring stocks (DFO 2009) this quantity of herring would be readily available from locally caught stocks. In 2007, four of the five herring stocks (i.e., White Bay-Notre Dame Bay, Bonavista Bay-Trinity Bay, St. Mary’s Bay-Placentia Bay, and Fortune Bay) had combined total landings of 6,346 t. A 2 lb 1:1 squid:herring bait combination in 2007 would have accounted for 33% of the landings for the Newfoundland and Labrador region.

The above cost benefit analyses assume that all fishermen in the Newfoundland and Labrador region use squid alone to bait their snow crab traps and that they typically use 2 lbs of squid. Although squid may be the preferred bait and as this study suggests for good reason, fishermen use a wide variety of bait configurations and configurations with and without bait protection devices. Alternative baits to squid include herring, mackerel, male capelin, cod frames, and turbot heads used separately and in combination with or without squid. Squid is usually placed on a skiver while the other bait types are typically placed in bait protection devices. We suggest that before any additional work is performed to verify the current results on a commercial scale that a telephone survey be conducted to determine current bait usage practices and general
opinion towards the use of a 1:1 ratio of squid and herring within the region. The survey would also provide a more accurate estimate of the cost benefit to the industry by promoting a 1:1 ratio of squid and herring as several fishermen may already be using this or a similar (squid and mackerel) bait configurations. Such a survey should include adequate representation of all vessel classes in the inshore and offshore sectors and in an attempt to maintain objectivity should be conducted by an independent arms length organization/institution.

Ultimately, to convince the harvesting sector of Newfoundland and Labradors snow crab fishery of the validity of changing from the use of squid alone to a 1:1 ratio of squid and herring will require a demonstration of the benefits at the commercial scale. Factors to consider when assessing catch rates of the two bait configurations at the commercial scale include the use or non-use of bait protection as well as the effects of soak time, bottom temperature, and substrate type. When squid is used it is commonly placed on skivers with no protection from scavenging sea lice, various scavenging species of fish, or snow crab as a pot fills, while in the current study all baits were placed in a large bait bag. The size of bait bag used in this study was based on the need for one bag to hold the maximum quantity of herring tested (2.3 kg) with bait bags used in the remaining bait configurations standardized to this requirement. It is unlikely that use of one or more smaller bait protection devices would have influenced the outcome of this study while placing squid on skivers may, particularly when traps are left to soak for a long period of time. In the offshore, traps are usually left to soak for 12-24 hours, similar to the current study while in inshore waters traps may soak for 48-72 hours. These differences may lead to differences in the performance of the different bait configurations with or without bait protection. Seemingly minor differences in bottom water temperatures and substrate can also lead to differences in catch rates related to the levels of activity and abundance of the legal size hard-shell crab such that differences in catch rates may not be related to the type of bait used but local habitat conditions. Due to the high variability in catch rates regardless of the bait configuration used a commercial scale demonstration of the validity of the use of a 1:1 ratio of squid and herring over the use of squid alone will require a quantitative analysis from several hauls similar to the approach used in the current study. Many of the underlying effects of the factors that can influence catch rates irrespective of bait configuration can be addressed by making available appropriate logbooks to skippers interested in participating in further analysis of the merit of a
A bait comparison study in Newfoundland and Labrador’s snow crab fishery

1:1 ratio of squid and herring and by providing a random group of these harvesters with researchers and/or observers to collect more detailed observations and data.

ACKNOWLEDGEMENTS

This study would not have seen the light of day without funding from Newfoundland and Labrador’s Department of Fisheries and Aquaculture (DFA). This study was conducted through collaboration on the part of the Marine Institute’s Centre for Sustainable Aquatic Resources (CSAR), the provincial Department of Fisheries and Aquaculture, the commercial fishing industry, and Fisheries and Oceans Canada (DFO). We would like to thank a number of individuals for their assistance during this study including Rennie Sullivan, Wayne DeGruchy, Georgina Bishop, Tara Perry, Paul Winger, and the skipper and crew of the CFV Island Voyager.

LITERATURE CITED


Walsh, P. 2001. Use of processed fish offal as bait in the Newfoundland snow crab (*Chionoecetes opilio*) fishery. Centre for Sustainable Aquatic Resources, Fisheries and Marine Institute of Memorial University of Newfoundland and Labrador, Canada. P-3, iii + 17p.
Table 1. Snow crab catch summary by fishing area (FA) in Conception Bay, 2009. Percent contribution of legal size hard-shell, legal size soft-shell, sublegal size male, and females to the total catch (kg) of snow crab across all fleet configuration and bait configurations is shown. Incidental bycatch (number of individuals) is also illustrated.

<table>
<thead>
<tr>
<th>FA</th>
<th>Dates Fished</th>
<th>No. of Hauls</th>
<th>Depth Range (m)</th>
<th>Legal size hard-shell %</th>
<th>Legal size soft-shell %</th>
<th>Sublegal males %</th>
<th>Females %</th>
<th>Bycatch (No.) Toad</th>
<th>Whelk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4-21 Jul</td>
<td>15</td>
<td>146 – 161</td>
<td>34.0</td>
<td>2.0</td>
<td>57.0</td>
<td>7.0</td>
<td>380</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>4-21 Jul</td>
<td>15</td>
<td>145 – 172</td>
<td>46.0</td>
<td>15.0</td>
<td>37.0</td>
<td>2.0</td>
<td>179</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>4-8 Jul</td>
<td>5</td>
<td>154 – 176</td>
<td>26.0</td>
<td>57.0</td>
<td>17.0</td>
<td>0.0</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>4-8 Jul</td>
<td>5</td>
<td>165 - 174</td>
<td>20.9</td>
<td>64.0</td>
<td>15.0</td>
<td>0.1</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>4-8 Jul</td>
<td>5</td>
<td>155 - 166</td>
<td>10.0</td>
<td>79.0</td>
<td>11.0</td>
<td>0.0</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>9-21 Jul</td>
<td>10</td>
<td>172 – 189</td>
<td>59.7</td>
<td>1.0</td>
<td>39.0</td>
<td>0.3</td>
<td>97</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>9-21 Jul</td>
<td>10</td>
<td>186 – 195</td>
<td>67.1</td>
<td>4.0</td>
<td>28.0</td>
<td>0.9</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>9-21 Jul</td>
<td>10</td>
<td>161 - 170</td>
<td>48.0</td>
<td>1.0</td>
<td>47.0</td>
<td>4.0</td>
<td>49</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 2. TAC (t), landings (t), effort (trap hauls), and CPUE (kg/trap) by year for Division 3L inshore and offshore (Table 8, from Dawe et al. 2009).

<table>
<thead>
<tr>
<th>Year</th>
<th>TAC Inshore</th>
<th>Landings Inshore</th>
<th>Effort Inshore</th>
<th>CPUE Inshore</th>
<th>TAC Offshore</th>
<th>Landings Offshore</th>
<th>Effort Offshore</th>
<th>CPUE Offshore</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>7.3</td>
<td>8.4</td>
<td>14.4</td>
<td>5.175</td>
<td>7.212</td>
<td>389,838</td>
<td>18.5</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>6.9</td>
<td>10.2</td>
<td>10.9</td>
<td>14.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>11.7</td>
<td>16.0</td>
<td>16.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>14.4</td>
<td>16.2</td>
<td>16.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>6,795</td>
<td>6,795</td>
<td>471,875</td>
<td>14.4</td>
<td>7,212</td>
<td>389,838</td>
<td>18.5</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>7,922</td>
<td>665,714</td>
<td>11.9</td>
<td>7,100</td>
<td>8,494</td>
<td>534,214</td>
<td>15.9</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>6,398</td>
<td>627,255</td>
<td>10.2</td>
<td>13,075</td>
<td>14,293</td>
<td>893,313</td>
<td>16.0</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>6,879</td>
<td>582,966</td>
<td>11.8</td>
<td>12,750</td>
<td>16,410</td>
<td>948,555</td>
<td>17.3</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>5,453</td>
<td>482,566</td>
<td>11.3</td>
<td>21,025</td>
<td>20,767</td>
<td>1,173,277</td>
<td>17.7</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>4,731</td>
<td>407,845</td>
<td>11.6</td>
<td>18,077</td>
<td>17,869</td>
<td>930,677</td>
<td>19.2</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>5,546</td>
<td>518,318</td>
<td>10.7</td>
<td>18,040</td>
<td>17,923</td>
<td>958,449</td>
<td>18.7</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>6,525</td>
<td>582,589</td>
<td>11.2</td>
<td>19,908</td>
<td>18,488</td>
<td>1,010,273</td>
<td>18.3</td>
<td></td>
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<tr>
<td>2003</td>
<td>6,818</td>
<td>841,728</td>
<td>8.1</td>
<td>21,033</td>
<td>19,228</td>
<td>1,158,313</td>
<td>16.6</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>6,421</td>
<td>823,205</td>
<td>7.8</td>
<td>21,033</td>
<td>19,325</td>
<td>1,351,399</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>6,114</td>
<td>745,610</td>
<td>8.2</td>
<td>21,033</td>
<td>18,795</td>
<td>1,352,158</td>
<td>13.9</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>6,229</td>
<td>648,854</td>
<td>9.6</td>
<td>21,033</td>
<td>20,250</td>
<td>1,511,194</td>
<td>13.4</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>6,485</td>
<td>600,463</td>
<td>10.8</td>
<td>21,033</td>
<td>20,353</td>
<td>1,739,573</td>
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</table>
Table 3. Summary of two-way analyses of variance (ANOVA’s) to test the effect of fishing area (FA) and week on mean CPUE (kg/trap) of legal size hard-shell snow crab captured in four bait treatments of commercial fleets in Conception Bay, July 2009.

<table>
<thead>
<tr>
<th>Source</th>
<th>Source Type</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-value</th>
<th>Probability value p</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 lbs squid</td>
<td>FA</td>
<td>3.903</td>
<td>7</td>
<td>0.558</td>
<td>38.613</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.166</td>
<td>2</td>
<td>0.083</td>
<td>5.733</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.226</td>
<td>5</td>
<td>0.045</td>
<td>3.131</td>
<td>0.009*</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>4.115</td>
<td>285</td>
<td>0.014</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>159.504</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lbs herring</td>
<td>FA</td>
<td>2.349</td>
<td>7</td>
<td>0.336</td>
<td>25.790</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.191</td>
<td>2</td>
<td>0.095</td>
<td>7.330</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.493</td>
<td>5</td>
<td>0.099</td>
<td>7.572</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>3.670</td>
<td>282</td>
<td>0.013</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Total</td>
<td>123.889</td>
<td>297</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5 lbs herring</td>
<td>FA</td>
<td>1.618</td>
<td>7</td>
<td>0.231</td>
<td>15.364</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.835</td>
<td>2</td>
<td>0.417</td>
<td>27.735</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.360</td>
<td>5</td>
<td>0.072</td>
<td>4.786</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>4.274</td>
<td>284</td>
<td>0.015</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>148.696</td>
<td>299</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lbs 1:1 squid:herring</td>
<td>FA</td>
<td>2.545</td>
<td>7</td>
<td>0.364</td>
<td>24.047</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.248</td>
<td>2</td>
<td>0.124</td>
<td>8.199</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.370</td>
<td>5</td>
<td>0.074</td>
<td>4.900</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>4.278</td>
<td>283</td>
<td>0.015</td>
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</tr>
<tr>
<td></td>
<td>Total</td>
<td>165.562</td>
<td>298</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significantly different at the 0.05 probability level
Table 4. Summary of two-way analyses of variance (ANOVA’s) to test the effect of fishing area (FA) and week on mean CPUE (kg/trap) of sublegal size male snow crab captured in four bait treatments of commercial fleets in Conception Bay, July 2009.

<table>
<thead>
<tr>
<th>Bait configuration</th>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-value</th>
<th>Probability value</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 lbs squid</td>
<td>FA</td>
<td>2.308</td>
<td>7</td>
<td>0.330</td>
<td>31.104</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.113</td>
<td>2</td>
<td>0.056</td>
<td>5.329</td>
<td>0.005*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.406</td>
<td>5</td>
<td>0.081</td>
<td>7.655</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>3.021</td>
<td>285</td>
<td>0.011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>132.440</td>
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<tr>
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<td>1.116</td>
<td>7</td>
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<td>17.815</td>
<td>&lt;0.001*</td>
<td></td>
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<tr>
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<td>Week</td>
<td>0.421</td>
<td>2</td>
<td>0.211</td>
<td>23.541</td>
<td>&lt;0.001*</td>
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</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.311</td>
<td>5</td>
<td>0.062</td>
<td>6.942</td>
<td>&lt;0.001*</td>
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<td>2.524</td>
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<td>0.009</td>
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<td>112.491</td>
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<td></td>
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<td>0.732</td>
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<td>0.105</td>
<td>9.874</td>
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<tr>
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<td>Week</td>
<td>0.110</td>
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<td>0.055</td>
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<tr>
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<td>FA × Week</td>
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<td>Week</td>
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<td>FA × Week</td>
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<td>0.046</td>
<td>4.169</td>
<td>0.001*</td>
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</tr>
<tr>
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<td>Error</td>
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<td>283</td>
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<td>Total</td>
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<td>298</td>
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*significantly different at the 0.05 probability level
Table 5. Summary of one-way analyses of variance (ANOVA’s) to test the effect of week on mean CPUE (kg/trap) within FA and bait configuration for two categories of snow crab captured in commercial fleets in five fishing areas (FA; see Figures 3 and 4) in Conception Bay, July 2009.

<table>
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<tr>
<th>Bait configuration</th>
<th>FA</th>
<th>Legal size hard-shell F</th>
<th>d.f.</th>
<th>p</th>
<th>Sublegal size male F</th>
<th>d.f.</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2 lbs squid</td>
<td>1</td>
<td>4.216</td>
<td>2,57</td>
<td>0.020*</td>
<td>5.051</td>
<td>2,57</td>
<td>0.010*</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.103</td>
<td>2,57</td>
<td>0.339</td>
<td>5.001</td>
<td>2,57</td>
<td>0.010*</td>
</tr>
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<td></td>
<td>6</td>
<td>10.286</td>
<td>1,38</td>
<td>0.003*</td>
<td>8.842</td>
<td>1,38</td>
<td>0.005*</td>
</tr>
<tr>
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<td>7</td>
<td>2.948</td>
<td>1,38</td>
<td>0.094</td>
<td>15.073</td>
<td>1,38</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>0.934</td>
<td>1,38</td>
<td>0.340</td>
<td>0.907</td>
<td>1,38</td>
<td>0.347</td>
</tr>
<tr>
<td>2 lbs herring</td>
<td>1</td>
<td>0.812</td>
<td>2,57</td>
<td>0.449</td>
<td>2.798</td>
<td>2,57</td>
<td>0.069</td>
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<tr>
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<td>0.485</td>
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<td>0.619</td>
<td>10.703</td>
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<td>&lt;0.001*</td>
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<td>2.817</td>
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<td>0.101</td>
<td>14.866</td>
<td>1,38</td>
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<tr>
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<td>7</td>
<td>11.292</td>
<td>1,37</td>
<td>0.002*</td>
<td>37.392</td>
<td>1,37</td>
<td>&lt;0.001*</td>
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<td>10.102</td>
<td>1,37</td>
<td>0.003*</td>
</tr>
<tr>
<td>5 lbs herring</td>
<td>1</td>
<td>19.966</td>
<td>2,57</td>
<td>&lt;0.001*</td>
<td>5.673</td>
<td>2,57</td>
<td>0.006*</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>17.214</td>
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<td>&lt;0.001*</td>
<td>1.289</td>
<td>2,56</td>
<td>0.284</td>
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<tr>
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<td>6</td>
<td>0.074</td>
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<td>0.787</td>
<td>0.076</td>
<td>1,38</td>
<td>0.784</td>
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<td>0.001*</td>
<td>1.028</td>
<td>1,38</td>
<td>0.317</td>
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<td>8</td>
<td>1.499</td>
<td>1,38</td>
<td>0.228</td>
<td>0.061</td>
<td>1,38</td>
<td>0.807</td>
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<td>0.970</td>
<td>2,57</td>
<td>0.385</td>
<td>5.812</td>
<td>2,57</td>
<td>0.005*</td>
</tr>
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<td></td>
<td>2</td>
<td>11.837</td>
<td>2,57</td>
<td>&lt;0.001*</td>
<td>3.953</td>
<td>2,57</td>
<td>0.025*</td>
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<tr>
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<td>6</td>
<td>0.023</td>
<td>1,38</td>
<td>0.879</td>
<td>1.194</td>
<td>1,38</td>
<td>0.281</td>
</tr>
<tr>
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<td>7</td>
<td>1.797</td>
<td>1,37</td>
<td>0.188</td>
<td>0.477</td>
<td>1,37</td>
<td>0.494</td>
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<td>8</td>
<td>7.524</td>
<td>1,37</td>
<td>0.009*</td>
<td>0.042</td>
<td>1,37</td>
<td>0.839</td>
</tr>
</tbody>
</table>

*significantly different at the 0.05 probability level
Table 6. Summary of one-way analyses of variance (ANOVA’s) to test the effect of fishing area on mean CPUE (kg/trap) within weeks 1-3 and bait configuration for two categories of snow crab captured in commercial fleets in five fishing areas (see Figures 3 and 4) in Conception Bay, July 2009.

| Bait configuration | Week | Legal size hard-shell | | | Sublegal size male | | |
|-------------------|------|-----------------------|---|----------|-------------------|---|
|                   |      | F         | d.f. | p       | F          | d.f. | p   |
| 2 lbs squid       | 1    | 20.925    | 4.95 | <0.001* | 45.426     | 4.95 | <0.001* |
|                   | 2    | 22.073    | 4.95 | <0.001* | 16.946     | 4.95 | <0.001* |
|                   | 3    | 28.490    | 4.95 | <0.001* | 6.013      | 4.95 | <0.001* |
| 2 lbs herring     | 1    | 14.409    | 4.95 | <0.001* | 27.592     | 4.95 | <0.001* |
|                   | 2    | 25.657    | 4.93 | <0.001* | 0.458      | 4.93 | 0.766    |
|                   | 3    | 14.730    | 4.94 | <0.001* | 14.316     | 4.94 | <0.001* |
| 5 lbs herring     | 1    | 4.402     | 4.94 | 0.003*   | 13.289     | 4.94 | <0.001* |
|                   | 2    | 15.282    | 4.95 | <0.001* | 4.079      | 4.95 | 0.004*   |
|                   | 3    | 11.617    | 4.95 | <0.001* | 2.425      | 4.95 | 0.053    |
| 2 lbs 1:1 squid:herring | 1 | 17.347 | 4.95 | <0.001* | 12.804 | 4.95 | <0.001* |
|                   | 2    | 9.451     | 4.93 | <0.001* | 3.487      | 4.93 | 0.011*   |
|                   | 3    | 23.623    | 4.95 | <0.001* | 5.229      | 4.95 | 0.001*   |

*significantly different at the 0.05 probability level
A bait comparison study in Newfoundland and Labrador’s snow crab fishery

Table 7. Summary of one-way analyses of variance (ANOVA’s) to test the effect of bait configuration on mean CPUE (kg/trap) of three categories of snow crab captured in commercial fleets within five fishing areas (see Figures 3 and 4) in Conception Bay, July 2009. See Figures 8-10 (legal size hard-shell), 14 (legal size soft-shell) and 20-22 (sublegal size male) for corresponding homogeneous sub-sets.

<table>
<thead>
<tr>
<th>Week</th>
<th>FA</th>
<th>Legal size hard-shell</th>
<th></th>
<th></th>
<th></th>
<th>Legal size soft-shell</th>
<th></th>
<th></th>
<th>Sublegal size male</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>d.f.</td>
<td>p</td>
<td></td>
<td>F</td>
<td>d.f.</td>
<td>p</td>
<td></td>
<td>F</td>
<td>d.f.</td>
<td>p</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>4.56</td>
<td>3.76</td>
<td>0.005*</td>
<td>0.24</td>
<td>3.76</td>
<td>0.866</td>
<td>7.12</td>
<td>3.76</td>
<td>&lt;0.001*</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7.70</td>
<td>3.75</td>
<td>&lt;0.001*</td>
<td>8.03</td>
<td>3.75</td>
<td>&lt;0.001*</td>
<td>2.05</td>
<td>3.75</td>
<td>0.115</td>
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<td>3</td>
<td>19.80</td>
<td>3.76</td>
<td>&lt;0.001*</td>
<td>2.48</td>
<td>3.76</td>
<td>0.067</td>
<td>5.97</td>
<td>3.76</td>
<td>0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>18.63</td>
<td>3.76</td>
<td>&lt;0.001*</td>
<td>26.04</td>
<td>3.76</td>
<td>&lt;0.001*</td>
<td>39.43</td>
<td>3.76</td>
<td>&lt;0.001*</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3.11</td>
<td>3.76</td>
<td>&lt;0.001*</td>
<td>0.38</td>
<td>3.76</td>
<td>0.770</td>
<td>8.69</td>
<td>3.76</td>
<td>&lt;0.001*</td>
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</tr>
<tr>
<td>2</td>
<td>1</td>
<td>17.90</td>
<td>3.76</td>
<td>&lt;0.001*</td>
<td>8.31</td>
<td>3.76</td>
<td>&lt;0.001*</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5.50</td>
<td>3.76</td>
<td>0.002*</td>
<td>2.28</td>
<td>3.75</td>
<td>0.086</td>
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<td>6</td>
<td>6.97</td>
<td>3.76</td>
<td>&lt;0.001*</td>
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<td>3.74</td>
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<td>5.06</td>
<td>3.74</td>
<td>0.003*</td>
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<td>9.47</td>
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<td>3.75</td>
<td>0.022*</td>
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</tr>
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<td>0.81</td>
<td>3.76</td>
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<td>6.24</td>
<td>3.76</td>
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<td>7.26</td>
<td>3.76</td>
<td>&lt;0.001*</td>
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<td>5.49</td>
<td>3.76</td>
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<td>12.73</td>
<td>3.76</td>
<td>&lt;0.001*</td>
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<td>3.76</td>
<td>&lt;0.001*</td>
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<td></td>
</tr>
<tr>
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<td>8</td>
<td>2.25</td>
<td>3.75</td>
<td>0.090</td>
<td>7.36</td>
<td>3.75</td>
<td>&lt;0.001*</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*significantly different at the 0.05 probability level
Table 8. Summary of two-way analyses of variance (ANOVA’s) to test the effect of fishing area (FA) and week on mean CPUE (kg/trap) of legal size hard-shell snow crab in four bait configurations of a science fleet in Conception Bay, July 2009.

<table>
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<tr>
<th>Bait configuration</th>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-value</th>
<th>Probability value p</th>
</tr>
</thead>
<tbody>
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<td>2 lbs squid</td>
<td>FA</td>
<td>0.704</td>
<td>7</td>
<td>0.101</td>
<td>4.646</td>
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<tr>
<td></td>
<td>Week</td>
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<td>0.016</td>
<td>0.732</td>
<td>0.485</td>
</tr>
<tr>
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<td>FA × Week</td>
<td>0.240</td>
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<td>0.048</td>
<td>2.218</td>
<td>0.064</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>1.299</td>
<td>60</td>
<td>0.022</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
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<td>75</td>
<td></td>
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<td>0.121</td>
<td>8.995</td>
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<tr>
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<td>Week</td>
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<td>1.594</td>
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<tr>
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<td>FA × Week</td>
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<td>0.030</td>
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<tr>
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<td>Total</td>
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<td>8.675</td>
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<td>0.019*</td>
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<td>0.016</td>
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<td>75</td>
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<td>0.208</td>
<td>9.655</td>
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<td>Week</td>
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<td>2</td>
<td>0.009</td>
<td>0.403</td>
<td>0.670</td>
</tr>
<tr>
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<td>FA × Week</td>
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<td>0.026</td>
<td>1.202</td>
<td>0.320</td>
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<tr>
<td></td>
<td>Error</td>
<td>1.269</td>
<td>59</td>
<td>0.022</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40.104</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significantly different at the 0.05 probability level
Table 9. Summary of two-way analyses of variance (ANOVA’s) to test the effect of fishing area (FA) and week on mean CPUE (kg/trap) of sublegal snow crab in four bait configurations of a science fleet in Conception Bay, July 2009.

<table>
<thead>
<tr>
<th>Bait configuration</th>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-value</th>
<th>Probability value p</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 lbs squid</td>
<td>FA</td>
<td>0.247</td>
<td>7</td>
<td>0.035</td>
<td>1.686</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.076</td>
<td>2</td>
<td>0.038</td>
<td>1.814</td>
<td>0.172</td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.026</td>
<td>5</td>
<td>0.005</td>
<td>0.247</td>
<td>0.940</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>1.254</td>
<td>60</td>
<td>0.021</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36.514</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lbs herring</td>
<td>FA</td>
<td>0.252</td>
<td>7</td>
<td>0.036</td>
<td>4.592</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.038</td>
<td>2</td>
<td>0.019</td>
<td>2.419</td>
<td>0.098</td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.060</td>
<td>5</td>
<td>0.012</td>
<td>1.518</td>
<td>0.198</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.455</td>
<td>58</td>
<td>0.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>30.669</td>
<td>73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 lbs herring</td>
<td>FA</td>
<td>0.368</td>
<td>7</td>
<td>0.053</td>
<td>4.792</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.044</td>
<td>2</td>
<td>0.022</td>
<td>2.020</td>
<td>0.142</td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.090</td>
<td>5</td>
<td>0.018</td>
<td>1.646</td>
<td>0.162</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.659</td>
<td>60</td>
<td>0.011</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>35.742</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lbs 1:1 squid:herring</td>
<td>FA</td>
<td>0.318</td>
<td>7</td>
<td>0.045</td>
<td>2.624</td>
<td>0.020*</td>
</tr>
<tr>
<td></td>
<td>Week</td>
<td>0.025</td>
<td>2</td>
<td>0.012</td>
<td>0.720</td>
<td>0.491</td>
</tr>
<tr>
<td></td>
<td>FA × Week</td>
<td>0.060</td>
<td>5</td>
<td>0.012</td>
<td>0.697</td>
<td>0.628</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>1.021</td>
<td>59</td>
<td>0.017</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>33.509</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significantly different at the 0.05 probability level
A bait comparison study in Newfoundland and Labrador’s snow crab fishery

Table 10. Summary of one-way analyses of variance (ANOVA’s) to test the effect of bait configuration on mean CPUE (kg/trap) of three categories of snow crab in science fleets within five fishing areas (see Figures 3 and 4) in Conception Bay, July 2009. See text for justification for pooling the data.

<table>
<thead>
<tr>
<th>Week</th>
<th>FA</th>
<th>Legal size hard-shell</th>
<th>Legal size soft-shell</th>
<th>Sublegal size male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>d.f.</td>
<td>p</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.69</td>
<td>3,54</td>
<td>0.181</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1.68</td>
<td>3,16</td>
<td>0.212</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0.43</td>
<td>3,15</td>
<td>0.733</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.10</td>
<td>3,16</td>
<td>0.377</td>
</tr>
</tbody>
</table>

Sublegal males

<table>
<thead>
<tr>
<th>Pooled Data</th>
<th>F</th>
<th>d.f.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1-3</td>
<td>1</td>
<td>1.69</td>
<td>3,54</td>
</tr>
<tr>
<td>Week 1-3</td>
<td>2</td>
<td>0.72</td>
<td>3,56</td>
</tr>
<tr>
<td>Week 2-3</td>
<td>6</td>
<td>0.63</td>
<td>3,36</td>
</tr>
<tr>
<td>Week 2-3</td>
<td>7</td>
<td>0.68</td>
<td>3,36</td>
</tr>
<tr>
<td>Week 2-3</td>
<td>8</td>
<td>1.52</td>
<td>3,35</td>
</tr>
</tbody>
</table>
Table 11. Weekly summary of the catch (kg) of snow crab in commercial fleets by bait configuration, body size, and shell condition. Weekly values are summed over five commercial fleets of 20 traps (i.e., 100 traps/week). Bait configurations are presented in a rank order from the lowest to highest total catch of legal size hard-shell crab over the three week period.

<table>
<thead>
<tr>
<th>Week 1</th>
<th>2 lbs herring</th>
<th>5 lbs herring</th>
<th>2 lbs squid</th>
<th>2 lbs 1:1 squid:herring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal size hard-shell</td>
<td>148</td>
<td>177</td>
<td>239</td>
<td>261</td>
</tr>
<tr>
<td>Legal size soft-shell</td>
<td>400</td>
<td>455</td>
<td>502</td>
<td>328</td>
</tr>
<tr>
<td>Sublegal size male</td>
<td>154</td>
<td>205</td>
<td>211</td>
<td>243</td>
</tr>
<tr>
<td>Total</td>
<td>701</td>
<td>837</td>
<td>952</td>
<td>831</td>
</tr>
<tr>
<td>Week 2</td>
<td>2 lbs herring</td>
<td>5 lbs herring</td>
<td>2 lbs squid</td>
<td>2 lbs 1:1 squid:herring</td>
</tr>
<tr>
<td>Legal size hard-shell</td>
<td>341</td>
<td>451</td>
<td>451</td>
<td>456</td>
</tr>
<tr>
<td>Legal size soft-shell</td>
<td>22</td>
<td>46</td>
<td>66</td>
<td>67</td>
</tr>
<tr>
<td>Sublegal size male</td>
<td>292</td>
<td>332</td>
<td>335</td>
<td>320</td>
</tr>
<tr>
<td>Total</td>
<td>655</td>
<td>829</td>
<td>852</td>
<td>843</td>
</tr>
<tr>
<td>Week 3</td>
<td>2 lbs herring</td>
<td>5 lbs herring</td>
<td>2 lbs squid</td>
<td>2 lbs 1:1 squid:herring</td>
</tr>
<tr>
<td>Legal size hard-shell</td>
<td>263</td>
<td>340</td>
<td>375</td>
<td>395</td>
</tr>
<tr>
<td>Legal size soft-shell</td>
<td>24</td>
<td>45</td>
<td>23</td>
<td>46</td>
</tr>
<tr>
<td>Sublegal size male</td>
<td>202</td>
<td>300</td>
<td>268</td>
<td>328</td>
</tr>
<tr>
<td>Total</td>
<td>489</td>
<td>685</td>
<td>666</td>
<td>769</td>
</tr>
<tr>
<td>Week 1-3</td>
<td>2 lbs herring</td>
<td>5 lbs herring</td>
<td>2 lbs squid</td>
<td>2 lbs 1:1 squid:herring</td>
</tr>
<tr>
<td>Legal size hard-shell</td>
<td>751</td>
<td>967</td>
<td>1,064</td>
<td>1,112</td>
</tr>
<tr>
<td>Legal size soft-shell</td>
<td>446</td>
<td>546</td>
<td>592</td>
<td>441</td>
</tr>
<tr>
<td>Sublegal size male</td>
<td>647</td>
<td>837</td>
<td>814</td>
<td>891</td>
</tr>
<tr>
<td>Total</td>
<td>1,845</td>
<td>2,350</td>
<td>2,470</td>
<td>2,444</td>
</tr>
</tbody>
</table>
Table 12. Weekly summary of the catch (kg) of snow crab in science fleets by bait configuration, body size, and shell condition. Weekly values are summed over five science fleets with five replicates per bait configuration (i.e., 25 traps/week). Bait configurations are presented in a rank order from the lowest to highest total catch of legal size hard-shell crab over the three week period.

<table>
<thead>
<tr>
<th></th>
<th>2 lbs herring</th>
<th>5 lbs herring</th>
<th>2 lbs squid</th>
<th>2 lbs 1:1 squid:herring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal size hard-shell</td>
<td>53</td>
<td>69</td>
<td>61</td>
<td>72</td>
</tr>
<tr>
<td>Legal size soft-shell</td>
<td>76</td>
<td>100</td>
<td>111</td>
<td>78</td>
</tr>
<tr>
<td>Sublegal size male</td>
<td>44</td>
<td>53</td>
<td>58</td>
<td>51</td>
</tr>
<tr>
<td>Total</td>
<td>173</td>
<td>222</td>
<td>230</td>
<td>201</td>
</tr>
<tr>
<td><strong>Week 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal size hard-shell</td>
<td>82</td>
<td>105</td>
<td>98</td>
<td>117</td>
</tr>
<tr>
<td>Legal size soft-shell</td>
<td>5</td>
<td>6</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Sublegal size male</td>
<td>70</td>
<td>93</td>
<td>74</td>
<td>95</td>
</tr>
<tr>
<td>Total</td>
<td>156</td>
<td>204</td>
<td>185</td>
<td>222</td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal size hard-shell</td>
<td>94</td>
<td>90</td>
<td>114</td>
<td>99</td>
</tr>
<tr>
<td>Legal size soft-shell</td>
<td>8</td>
<td>8</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Sublegal size male</td>
<td>69</td>
<td>79</td>
<td>76</td>
<td>87</td>
</tr>
<tr>
<td>Total</td>
<td>171</td>
<td>176</td>
<td>206</td>
<td>205</td>
</tr>
<tr>
<td><strong>Week 1-3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal size hard-shell</td>
<td>229</td>
<td>263</td>
<td>272</td>
<td>288</td>
</tr>
<tr>
<td>Legal size soft-shell</td>
<td>88</td>
<td>114</td>
<td>142</td>
<td>107</td>
</tr>
<tr>
<td>Sublegal size male</td>
<td>183</td>
<td>224</td>
<td>207</td>
<td>232</td>
</tr>
<tr>
<td>Total</td>
<td>500</td>
<td>601</td>
<td>621</td>
<td>628</td>
</tr>
</tbody>
</table>
Table 13. Summary of two-way analyses of variance (ANOVA’s) to test the effect of fleet type (commercial and science) and bait configuration on mean percent contribution of legal size soft-shell snow crab to the total catch (kg) during week 1 and weeks 1-3 combined in Conception Bay, July 2009.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-value</th>
<th>Probability Value p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet</td>
<td>0.040</td>
<td>1</td>
<td>0.040</td>
<td>0.193</td>
<td>0.661</td>
</tr>
<tr>
<td>Bait</td>
<td>0.149</td>
<td>3</td>
<td>0.050</td>
<td>0.241</td>
<td>0.868</td>
</tr>
<tr>
<td>SC × Bait</td>
<td>0.922</td>
<td>3</td>
<td>0.307</td>
<td>1.487</td>
<td>0.217</td>
</tr>
<tr>
<td>Error</td>
<td>101.534</td>
<td>491</td>
<td>0.207</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>299.305</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weeks 1 - 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet</td>
<td>0.003</td>
<td>1</td>
<td>0.003</td>
<td>0.023</td>
<td>0.880</td>
</tr>
<tr>
<td>Bait</td>
<td>0.154</td>
<td>3</td>
<td>0.051</td>
<td>0.343</td>
<td>0.795</td>
</tr>
<tr>
<td>SC × Bait</td>
<td>0.407</td>
<td>3</td>
<td>0.136</td>
<td>0.907</td>
<td>0.437</td>
</tr>
<tr>
<td>Error</td>
<td>221.590</td>
<td>1482</td>
<td>0.150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>352.540</td>
<td>1490</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 14. Summary of two-way analyses of variance (ANOVA’s) to test the effect of fleet type (commercial and science) and bait configuration on mean percent contribution of sublegal size male snow crab to the total catch (kg) during weeks 1, 2, and 3 and weeks 1-3 combined in Conception Bay, July 2009.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-value</th>
<th>Probability value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet</td>
<td>0.009</td>
<td>1</td>
<td>0.009</td>
<td>0.136</td>
<td>0.712</td>
</tr>
<tr>
<td>Bait</td>
<td>0.104</td>
<td>3</td>
<td>0.035</td>
<td>0.537</td>
<td>0.657</td>
</tr>
<tr>
<td>SC x Bait</td>
<td>0.201</td>
<td>3</td>
<td>0.067</td>
<td>1.040</td>
<td>0.374</td>
</tr>
<tr>
<td>Error</td>
<td>31.665</td>
<td>491</td>
<td>0.064</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>178.124</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Week 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet</td>
<td>0.016</td>
<td>1</td>
<td>0.016</td>
<td>0.534</td>
<td>0.465</td>
</tr>
<tr>
<td>Bait</td>
<td>0.269</td>
<td>3</td>
<td>0.090</td>
<td>2.910</td>
<td>0.034*</td>
</tr>
<tr>
<td>SC x Bait</td>
<td>0.068</td>
<td>3</td>
<td>0.023</td>
<td>0.733</td>
<td>0.533</td>
</tr>
<tr>
<td>Error</td>
<td>15.026</td>
<td>487</td>
<td>0.031</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>256.121</td>
<td>495</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet</td>
<td>0.000</td>
<td>1</td>
<td>0.000</td>
<td>0.005</td>
<td>0.944</td>
</tr>
<tr>
<td>Bait</td>
<td>0.066</td>
<td>3</td>
<td>0.022</td>
<td>0.680</td>
<td>0.564</td>
</tr>
<tr>
<td>SC x Bait</td>
<td>0.002</td>
<td>3</td>
<td>0.001</td>
<td>0.025</td>
<td>0.995</td>
</tr>
<tr>
<td>Error</td>
<td>15.715</td>
<td>488</td>
<td>0.032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>263.647</td>
<td>496</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weeks 1 - 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet</td>
<td>0.017</td>
<td>1</td>
<td>0.017</td>
<td>0.343</td>
<td>0.558</td>
</tr>
<tr>
<td>Bait</td>
<td>0.059</td>
<td>3</td>
<td>0.020</td>
<td>0.405</td>
<td>0.750</td>
</tr>
<tr>
<td>SC x Bait</td>
<td>0.091</td>
<td>3</td>
<td>0.030</td>
<td>0.620</td>
<td>0.602</td>
</tr>
<tr>
<td>Error</td>
<td>72.166</td>
<td>1482</td>
<td>0.049</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>697.893</td>
<td>1490</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significantly different at the 0.05 probability level
Table 15. Summary of the trap effort and potential savings by switching from 2 lbs squid to a 2 lb 1:1 squid:herring combination in the inshore and offshore snow crab fishing sectors of NAFO Division 3L from 1995-2007. Bait cost is based on $0.26 / lb for herring and $0.65 / lb for squid. Trap effort data from Dawe et al (2007).

<table>
<thead>
<tr>
<th>Year</th>
<th>Inshore Effort</th>
<th>Squid</th>
<th>1:1</th>
<th>Savings</th>
<th>Offshore Effort</th>
<th>Squid</th>
<th>1:1</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>471,875</td>
<td>613,438</td>
<td>429,406</td>
<td>184,031</td>
<td>389,838</td>
<td>506,789</td>
<td>354,753</td>
<td>152,037</td>
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<tr>
<td>1996</td>
<td>665,714</td>
<td>865,428</td>
<td>605,800</td>
<td>259,628</td>
<td>534,214</td>
<td>694,478</td>
<td>486,135</td>
<td>208,343</td>
</tr>
<tr>
<td>1997</td>
<td>627,255</td>
<td>815,432</td>
<td>570,802</td>
<td>244,629</td>
<td>893,313</td>
<td>1,161,307</td>
<td>812,915</td>
<td>348,392</td>
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<td>1998</td>
<td>582,966</td>
<td>757,856</td>
<td>530,499</td>
<td>227,357</td>
<td>948,555</td>
<td>1,233,122</td>
<td>863,185</td>
<td>369,936</td>
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<tr>
<td>1999</td>
<td>482,566</td>
<td>627,336</td>
<td>439,135</td>
<td>188,201</td>
<td>1,173,277</td>
<td>1,525,260</td>
<td>1,067,682</td>
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<td>2000</td>
<td>407,845</td>
<td>530,199</td>
<td>371,139</td>
<td>159,060</td>
<td>930,677</td>
<td>1,209,880</td>
<td>846,916</td>
<td>362,964</td>
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<td>673,813</td>
<td>471,669</td>
<td>202,144</td>
<td>958,449</td>
<td>1,245,984</td>
<td>872,189</td>
<td>373,795</td>
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<td>757,366</td>
<td>530,156</td>
<td>227,210</td>
<td>1,010,273</td>
<td>1,313,355</td>
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<tr>
<td>2003</td>
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<td>1,094,246</td>
<td>765,972</td>
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<td>1,158,313</td>
<td>1,505,807</td>
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<td>2004</td>
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<td>749,117</td>
<td>321,050</td>
<td>1,351,399</td>
<td>1,756,819</td>
<td>1,229,773</td>
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<tr>
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<td>745,610</td>
<td>969,293</td>
<td>678,505</td>
<td>290,788</td>
<td>1,352,158</td>
<td>1,757,805</td>
<td>1,230,464</td>
<td>527,342</td>
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<tr>
<td>2006</td>
<td>648,854</td>
<td>843,510</td>
<td>590,457</td>
<td>253,053</td>
<td>1,511,194</td>
<td>1,964,552</td>
<td>1,375,187</td>
<td>589,366</td>
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<td>2007</td>
<td>600,463</td>
<td>780,602</td>
<td>546,421</td>
<td>234,181</td>
<td>1,739,573</td>
<td>2,261,445</td>
<td>1,583,011</td>
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<td>Avg.</td>
<td>615,307</td>
<td>$799,899</td>
<td>$559,929</td>
<td>$239,970</td>
<td>1,073,172</td>
<td>$1,395,123</td>
<td>$976,586</td>
<td>$418,537</td>
</tr>
</tbody>
</table>
Figure 1. Traditional 1.2 m conical traps utilized in the Newfoundland and Labrador snow crab fishery.
Figure 2. A 15"L x 12"D bait protection bag illustrating the location of grommets and skivers for attaching to trap.
Figure 3. Map of study location in Conception Bay showing fishing areas 1-5 with fleet locations for week 1, July 4-9, 2009.
Figure 4. Map of study location in Conception Bay showing fishing areas 1, 2, and 6-8 with fleet locations for weeks 2 and 3, July 9-21, 2009.
Figure 5. Mean CPUE by bait treatment and fishing area of legal size hard-shell, legal size soft-shell, and sublegal male snow crab in commercial fleets fished in Conception Bay from 4-20 July 2009.
Figure 6. Mean CPUE by bait treatment and fishing area of legal size hard-shell, legal size soft-shell, and sublegal male snow crab in a science fleet fished in Conception Bay from 4-20 July 2009.
Figure 7. Temporal variation in mean CPUE (±1 SE) of legal size hard-shell snow crab by fishing area (FA) within Conception Bay (see Fig. 3 and 4) for a science fleet and commercial fleets baited with 2 lbs squid, 2 lbs 1:1 squid:herring, 2 lbs herring, and 5 lbs herring, July 2009.
Figure 8. Legal size hard-shell snow crab mean (±1SE) CPUE by bait configuration and fishing area (FA) in commercial and science fleets set for 24 hr during Week 1 (4-9 July) of a bait comparison study conducted in Conception Bay in 2009. An asterisk (*) indicates a significant difference (p<0.05) in CPUE between bait configurations within a FA and homogeneous subsets are also illustrated.
Figure 9. Legal size hard-shell snow crab mean (±1 SE) CPUE by bait configuration and fishing area (FA) in commercial and science fleets set for 24 hr (solid bars) and 72 hr (open bars) during Week 2 (9-16 July) of a bait comparison study conducted in Conception Bay in 2009. An asterisk (*) indicates a significant difference (p<0.05) in CPUE between bait configurations within a FA and homogeneous subsets are also illustrated.
A bait comparison study in Newfoundland and Labrador’s snow crab fishery

Figure 10. Legal size hard-shell snow crab mean (±1SE) CPUE by bait configuration and fishing area (FA) in commercial and science fleets set for 24 hr during Week 3 (16-21 July) of a bait comparison study conducted in Conception Bay in 2009. An asterisk (*) indicates a significant difference (p<0.05) in CPUE between bait configurations within a FA and homogeneous subsets are also illustrated.
A bait comparison study in Newfoundland and Labrador’s snow crab fishery

Figure 11. Weekly summary of the total catch (kg) of legal size hard-shell, legal size soft-shell, and sublegal male snow crab in commercial fleets in Conception Bay, July 2008.
Figure 12. Summary of the total catch (kg) of legal size hard-shell, legal size soft-shell, and sublegal male snow crab in a science fleet and commercial fleets over three consecutive weeks of fishing in Conception Bay, July 2008. Note, vertical axes are not equal.
Figure 13. Weekly summary of the total catch (kg) of legal size hard-shell, legal size soft-shell, and sublegal male snow crab in a science fleet in Conception Bay, July 2008.
Figure 14. Legal size soft-shell snow crab mean (±1 SE) CPUE by bait configuration and fishing area (FA) in commercial and science fleets set for 24 hr during Week 1 (4-9 July) of a bait comparison study conducted in Conception Bay in 2009. An asterisk (*) indicates a significant difference (p<0.05) in CPUE between bait configurations within a FA and homogeneous subsets are also illustrated.
Figure 15. Mean (±1 SE) percent contribution of legal size soft-shell snow crab to the total catch in commercial and science fleets by bait configuration during Week 1 of a bait comparison study conducted in Conception Bay, July 2009.
Figure 16. Mean (±1 SE) percent contribution of legal size soft-shell snow crab to the total catch in commercial and science fleets by bait configuration over three consecutive weeks during a bait comparison study conducted in Conception Bay, July 2009.
Figure 17. Mean percent contribution of sublegal male snow crab to the total catch (kg) by fishing area and bait configuration, 4-20 July 2009.
Figure 18. Mean (±1 SE) percent contribution by bait configuration of sublegal size male snow crab to the weekly catch in commercial and science fleets set in Conception Bay, July 2009.
Figure 19. Mean (±1 SE) percent contribution by bait configuration of sublegal size male snow crab to the total catch (weeks 1-3) in commercial and science fleets set in Conception Bay, July 2009.
A bait comparison study in Newfoundland and Labrador’s snow crab fishery

Figure 20. Sublegal male snow crab mean (±1 SE) CPUE by bait configuration and fishing area (FA) in commercial and science fleets set for 24 hr during Week 1 (4-9 July) of a bait comparison study conducted in Conception Bay in 2009. An asterisk (*) indicates a significant difference (p<0.05) in CPUE between bait configurations within a FA and homogeneous subsets are also illustrated.
Figure 21. Sublegal male snow crab mean (±1 SE) CPUE by bait configuration and fishing area (FA) in commercial and science fleets set for 24 hr (solid bars) and 72 hr (open bars) during Week 2 (9-16 July) of a bait comparison study conducted in Conception Bay in 2009. An asterisk (*) indicates a significant difference (p<0.05) in CPUE between bait configurations within a FA and homogeneous subsets are also illustrated.
Figure 22. Sublegal male snow crab mean (±1 SE) CPUE by bait configuration and fishing area (FA) in commercial and science fleets set for 24 hr during Week 3 (16-21 July) of a bait comparison study conducted in Conception Bay in 2009. An asterisk (*) indicates a significant difference (p<0.05) in CPUE between bait configurations within a FA and homogeneous subsets are also illustrated.