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Research Document 2002/051 **Document de recherche 2002/051**

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A study of the catchability of snow crab by the Campelen 1800 survey trawl

Étude de la capturabilité du crabe des neiges par le chalut de relevé Campelen 1800

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ISSN 1480-4883

Abstract

An experiment was carried out during Sept. 2001 to estimate the catchability (trawl efficiency) of snow crab by the NAFC's (Northwest Atlantic Fisheries Centre) standard survey bottom trawl. The experiment involved towing secondary trawls directly behind the footgear of the Campelen 1800 shrimp trawl, which has been the NAFC's standard survey bottom trawl since 1995. Overall, catchability was found to be much lower than 1.0 and highly variable, with variability being strongly related to substrate type and snow crab size. Catchability increased with crab size and was higher on soft than on hard substrates. Three substrate-specific catchability functions were defined; 1) catchability was highest (about 0.9), and least dependent on crab size, on the softest (mud) substrate within a relatively deep depth stratum; 2) catchability was lower (about 0.5-0.7) and linearly related to crab size throughout most of the deeper stratum on a soft (sand/mud) substrate; 3) catchability was lowest (about 0-0.5) and most strongly related to crab size on a variety of hard substrates within a relatively shallow depth stratum. We recommend that further experiments of this type be conducted to fully elaborate the relationship of trawl efficiency with crab size and substrate type. This would provide a basis for standardizing survey catches for catchability effects and refining survey-based estimates of biomass and exploitation rates of snow crab.

Résumé

On a procédé à une expérience en septembre 2001 visant à estimer la capturabilité du crabe des neiges par le chalut de fond standard utilisé par le Centre des pêches de l'Atlantique nord-ouest (CPANO) pour faire les relevés. Des chaluts secondaires ont été traînés sur le fond directement derrière le chalut à crevettes Campelen 1800, qui est le chalut de fond standard utilisé par le CPANO depuis 1995. Dans l'ensemble, la capturabilité s'est révélée nettement inférieure à 1,0 et hautement variable, la variabilité étant en étroite corrélation avec le type de substrat et la taille du crabe des neiges. La capturabilité a augmenté en ligne avec la taille du crabe et était plus élevée sur des substrats mous que sur des substrats durs. Trois fonctions de la capturabilité spécifiques au type de substrat ont été identifiées : 1) la capturabilité était plus élevée (environ 0,9) et moins dépendante à la taille du crabe sur le substrat le plus mou (vase) d'une strate d'eau relativement profonde; 2) la capturabilité était plus faible (entre 0,5 et 0,7) et en relation linéaire avec la taille du crabe dans presque toute la strate d'eau profonde sur un substrat mou (sable/vase); 3) la capturabilité était la plus faible (entre 0 et 0,5) et en plus forte relation linéaire avec la taille du crabe sur une gamme de substrats durs dans une strate d'eau relativement peu profonde. Nous recommandons de procéder à d'autres expériences du genre afin d'établir clairement la relation entre l'efficacité du chalut, la taille du crabe et le type de substrat, ce qui permettrait de normaliser les prises de relevé en fonction des effets de la capturabilité et de peaufiner les estimations par relevé de la biomasse et des taux d'exploitation du crabe des neiges.

Introduction

Bottom trawls are commonly used as a survey tool for monitoring crab resources in the Eastern Bering Sea (Alverson and Pereyra 1969) and in Canadian Atlantic fishery areas. Bottom trawl surveys of Canadian Atlantic snow crab (*Chionoecetes opilio*) resources are conducted annually in the Southern Gulf of St. Lawrence (Moriyasu et al. 1999, Hébert et al. 2002), in the Northern Gulf of St. Lawrence (Dufour and Dallaire 1999), on the eastern Nova Scotian Shelf (Biron et al 2002), and on the Newfoundland-Labrador continental shelf (Dawe et al 2002, Dawe and Colbourne 2002). These surveys differ considerably among fishery areas with respect to their history (time series), design, spatial coverage of the resource, and gear used.

Multispecies bottom trawl surveys have been conducted annually on the Newfoundland-southern Labrador shelf since 1995, using the Campelen 1800 shrimp trawl. Campelen surveys have been conducted in fall (Sep-Dec) from the southern Labrador shelf to the southern Grand Bank (NAFO Divisions 2J3KLNO) since 1995 as well as during spring (Apr-June) on the Grand Bank and St. Pierre Bank (NAFO Divisions 3LNOPs) since 1996. These surveys follow a stratified random design, with stratification of the survey area based on depth and area (Doubleday 1981).

The fall Div. 2J3KLNO surveys have been used extensively in annual snow crab assessments (Dawe et al. 2002). However the spring Div. 3LNOPs surveys have not been useful for monitoring because they indicate unrealistic annual fluctuations in biomass that are characterized by very broad confidence intervals (Dawe et al. 2000). It is believed that catchability of snow crabs by the survey trawl is low and variable in spring, due to changes in behaviour associated with spring mating and molting. Annual changes in fall survey size-specific abundance and biomass indices suggest that catchability of crabs by the Campelen trawl in fall is considerably lower than 1.0, is annually variable, and varies with crab size. Somerton and Otto (1999) found that catchability of both snow crab and Tanner crab (*Chionecetes biardi*) by the Eastern Bering Sea survey trawl was strongly related to crab size.

In this paper we describe an experiment carried out using secondary trawls with the Campelen trawl to directly estimate catchability of snow crabs by that survey trawl. We also describe relationships of catchability with crab size and with substrate type.

Methodology

Experimental trawling was conducted during September 3-7, 2001 in NAFO Div. 3L (Fig. 1), aboard the Research Vessel *Wilfred Templeman* using the Campelen trawl. Three secondary trawls were attached below the lower belly and directly behind the footgear of the Campelen to collect crabs that had passed underneath. This experiment is very similar to one carried out by Walsh (1992) to estimate efficiency of a survey trawl for finfishes as well as to that conducted by Somerton and Otto (1999) to estimate efficiency of a survey trawl for snow crabs and Tanner crabs.

The Campelen 1800 survey trawl is a small-meshed (44, 60 and 80 mm) shrimp trawl that is equipped with a 12.7 mm mesh codend. It has an average wingspread of 15-18 m and an average vertical opening of 4-5 m, depending on depth fished (McCallum and Walsh, 2002). It has rockhopper footgear featuring 355 mm diameter rubber disks spaced at 200 mm intervals along the 35.6 m footrope.

Secondary trawls, of 44 mm mesh (Walsh 1992) were specifically constructed for this experiment. Three secondary trawls were attached to the Campelen trawl, beneath the port and starboard wings and the bosom, with the headrope of each secondary trawl attached to the fishing line of the Campelen. The three secondary trawls shared a common 8-in (200 mm) diameter rubber-encased cable footgear that was attached to both ends of the Campelen rockhopper footrope and loosely in the bosom to prevent damage during shooting and hauling. The secondary trawl footrope followed the Campelen footrope by about 0.5 m, at the center.

All experimental sets were comparable to standard survey sets with respect to trawling time (15 min), distance towed (0.75 nm), vessel speed (3 knots), and use of trawl-mounted monitoring devices (SCANMAR and CTD). The SCANMAR trawl monitoring system was used to determine trawl touch-down and lift-off and to measure trawl geometry throughout each set. Two bottom contact sensors were used during each set, affixed at various locations along the footrope of either the Campelen trawl or the secondary trawls. These devices monitored changes in angle throughout each tow and data downloaded after each set provided information on relative differences among tows in the degree of footrope contact with the substrate.

Initially, 7 experimental sets were executed on the northern Grand Bank (Fig. 1) with codends open to evaluate effects of secondary trawls on main trawl geometry. Sets with all codends closed to estimate catchability, were carried out in Conception Bay (Fig. 1). Within that bay two survey strata were sampled, with 7 successful sets in the deeper stratum (789; 184-366 m) and 5 successful sets in the shallower stratum (799; 93-183 m).

The sampling procedure at each station involved comparable treatment of the catches from all four codends (Campelen codend and 3 secondary trawl codends). Each catch was initially sorted by commercial species as well as by sex for snow crab. Snow crab catches were sampled in their entirety or subsampled by sex. Individuals of both sexes were measured in carapace width (CW, mm) and shell condition was assigned one of three categories: (1) newshelled - these crab had molted in spring of the current year, have a low meat yield throughout most of the fishing season, and legal-sized males (>94 mm CW) are generally not retained in the current fishery until fall; (2) intermediate-shelled – these crab last molted in the previous year and legal-sized males are fully recruited to the fishery throughout the current fishing season; (3) old-shelled – these crab last molted at least two years previously, and legal-sized males have been available to the fishery for at least 2 years. Males were also sampled for chela height (CH, 0.1 mm), and maturity status was determined for females.

Catchability by the Campelen trawl was estimated as the ratio of the Campelen trawl catch to the total catch from the Campelen plus secondary trawls. This assumes that catchability of the secondary trawls is 1.0. Male carapace widths were grouped into 3-mm intervals to examine the relationship of catchability with size.

The RoxAnn seabed classification system was used to classify substrate type according to roughness and hardness along each tow path as well as the entire cruise track. All available RoxAnn data from Conception Bay were utilised to define 6 substrate types ranging from the smoothest and softest bottom type to the roughest and hardest bottom type. The spatial distribution of substrate types in relation to survey strata and sampling stations was mapped. This technique was applied to all spring or fall multi-species survey sets at which Roxann data were collected throughout NAFO Div. 3L since 1995, to investigate the relationship of substrate type with depth across that broad area.

Results

The 7 initial sets with codends open showed no apparent effect of the secondary trawls on the doorspread or the vertical opening of the Campelen trawl. After the first 4 sets in Conception Bay with all codends closed, a suitable gear configuration appeared to have been achieved, in that gear damage became very rare.

Catchability in numbers of snow crabs across all sizes showed similar trends between the sexes among stations (Fig. 2). Catchability was higher in the deeper stratum (about 0.6-0.8) than in the shallower stratum (about 0.2). Catchability of snow crab was compared with that of American plaice (*Hippoglossoides platessoides*), the most frequently caught fish species in the experiment. American plaice showed a much higher catchability than snow crab (about 0.8-0.95) with no apparent difference between depth strata.

The effect of body size (CW) on catchability in the deeper stratum (789) was considered for the two stations of highest snow crab catchability separatetly from the other 5 stations of that stratum as these sets occurred at the inner-most stations of that stratum, and so they may have been associated with a unique substrate type.

Catchability of male snow crabs at the two innermost stations of the deeper stratum was virtually unrelated to carapace width (Fig. 3), and was quite high, approximately 0.9 across all sizes. We deduced that this high catchability was associated with an atypically soft (mud) substrate because the trawl catches at both these stations were heavily fouled by mud.

Catchability of males throughout most of the deeper stratum, based on 5 stations, was related to carapace width, but not strongly so (Fig. 3). A linear model adequately described that relationship and indicated that catchability decreased as size decreased from about 0.7 at largest size to about 0.5-0.6 at about 50-60 mm CW.

Catchability in the shallower stratum (799) was strongly related to carapace width (Fig. 4). This relationship was well described by a third order polynomial model that predicted catchabilities ranging from about 0.5 at 110 mm CW to about 0.1 at 40 mm CW, with catchabilitiy approaching zero for the smallest sizes.

The distribution of substrate types within Conception Bay (Fig. 5) indicates that a soft substrate is associated with the deeper stratum, whereas a variety of harder substrates are distributed throughout the shallower stratum. The substrate type categories established using RoxAnn data did not distinguish an atypically soft substrate at the two innermost stations of the deeper stratum.

The relationship of substrate type with depth throughout Div. 3L (Fig. 6) indicates that softest substrates are most common at 200-500 m depths, whereas hardest substrates are most common at shallower depths.

Discussion

Our experiment showed that catchability of snow crabs by the Campelen 1800 trawl was considerably lower than 1.0 at all stations with the exception of two in the deeper stratum with an atypically soft mud substrate. Catchability of males across most of the deeper stratum was higher than in the shallower stratum and did not vary greatly with body size. In contrast, catchability of males was strongly related to carapace width in the shallower stratum. This lower catchability and stronger relationship with size in the shallower stratum was associated with harder substrate types.. In general, and with the exception of the two deep stations with atypically soft substrate, catchability was highest (about 0.7) for the largest males (about 126 mm CW) at relatively great depths on soft substrates and was lowest (<0.1) for small males of <40 mm CW at shallower depths on harder substrates.

Although the 5 sets in our shallower stratum were executed on a variety of relatively hard substrates, there was a clear overall effect of size, across all male sizes between 12 and 115 mm CW. This suggests that catchability-at-size may be relatively invariant across a range of hard substrate types. If this is true, then it may be appropriate to pool across some of our harder substrate types to establish a minimum set of size-catchability relationships. If substrate types can be assigned to all survey strata, then the appropriate size-catchability relationship could be applied to each survey catch on the basis of stratum, to adjust all survey catches for catchability effects.

Our size-catchability relationships, again excluding that for the two deep stations with atypically soft substrate, were similar to relationships derived for both snow crab and Tanner crab (*Chionecetes biardi*) in the eastern Bering Sea (Somerton and Otto 1999) in that catchability was highest for largest crabs. However, their relationship with crab size, for sizes larger than about 50 mm CW, was stronger than our deep-stratum relationship. Also, their estimates of catchability-at-size were much higher than our shallow-stratum estimates. These differences probably reflect an eastern Bering Sea substrate that is not as soft as that of our deeper-stratum substrate, but softer and more uniform than that in our shallow stratum. Higher efficiency of the 83-112 Eastern Trawl used in the Bering Sea survey, may also be due to the much smaller and compact design of footrope (i.e. a rubber-encased cable, (Otto and Somerton 1999)) as opposed to the Campelen 1800's rockhopper footgear.

Our estimates of catchability or efficiency of the Campelen trawl are likely to represent maximum estimates. True efficiency is likely somewhat (or substantially) lower because the catchability of our secondary trawls, with a 200 mm diameter rubber footrope, is likely to be lower than 1.0. This is supported by the inefficiency of the Bering Sea 83-112 Eastern trawl with footgear apparently smaller than that of our secondary trawls (Otto and Somerton 1999).

We feel that further experiments of this type are needed to fully elaborate the relationship of trawl efficiency with crab size and substrate type. This would provide a basis for standardizing survey catches for catchability effects and refining survey-based estimates of biomass and exploitation rates of snow crab.

Acknowledgements

We wish to acknowledge Scott Mcentire of NOAA (National Oceanic and Atmospheric Administration) for his technical support and kind loan of the bottom contact sensors.

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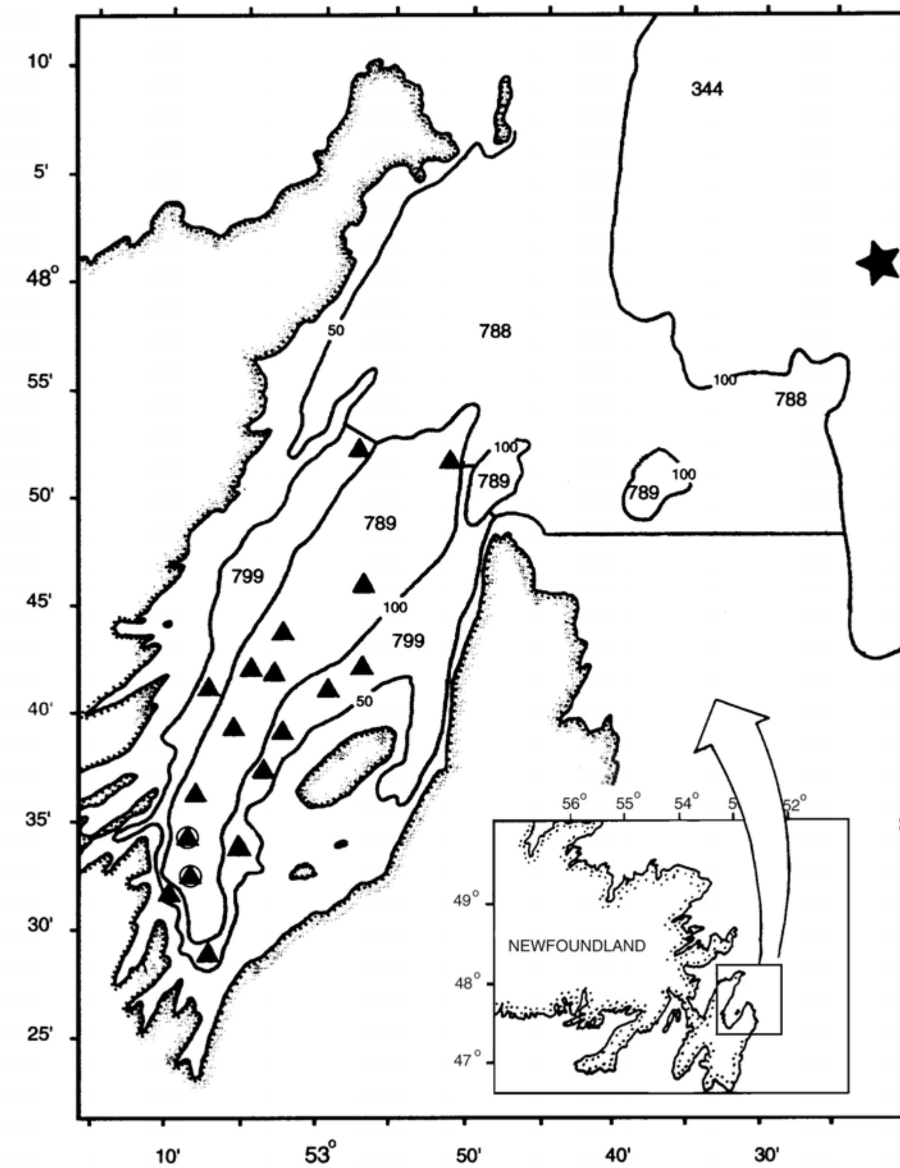

Fig. 1. Location map showing the northern Grand Bank experimental site (star) and the location of successful sets for estimating catchability (trawl efficiency) within two strata in Conception Bay (triangles). The circled triangles represent the two sets of highest catchability in the deeper stratum.

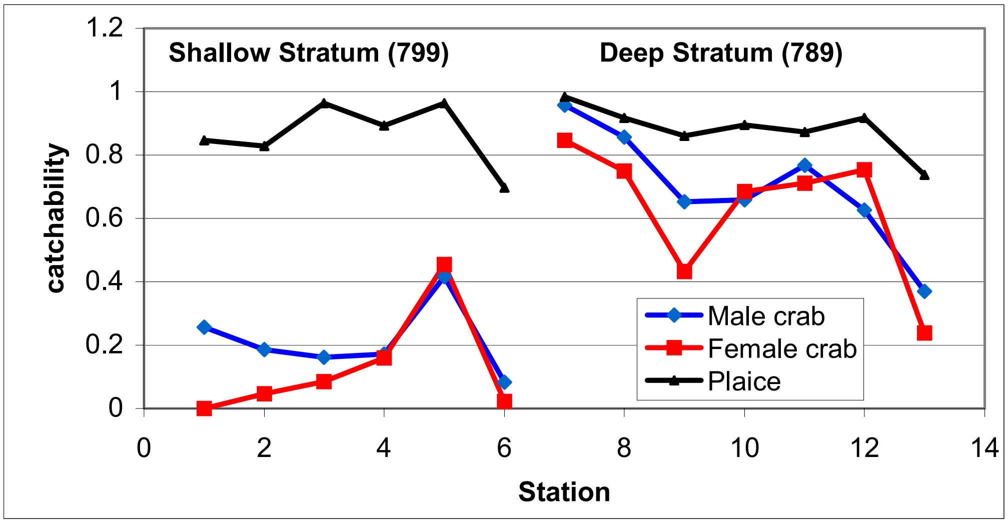

Fig. 2. Estimates of efficiency across all sizes at each station within two depth strata for each of male and female snow crabs and unsexed american plaice.

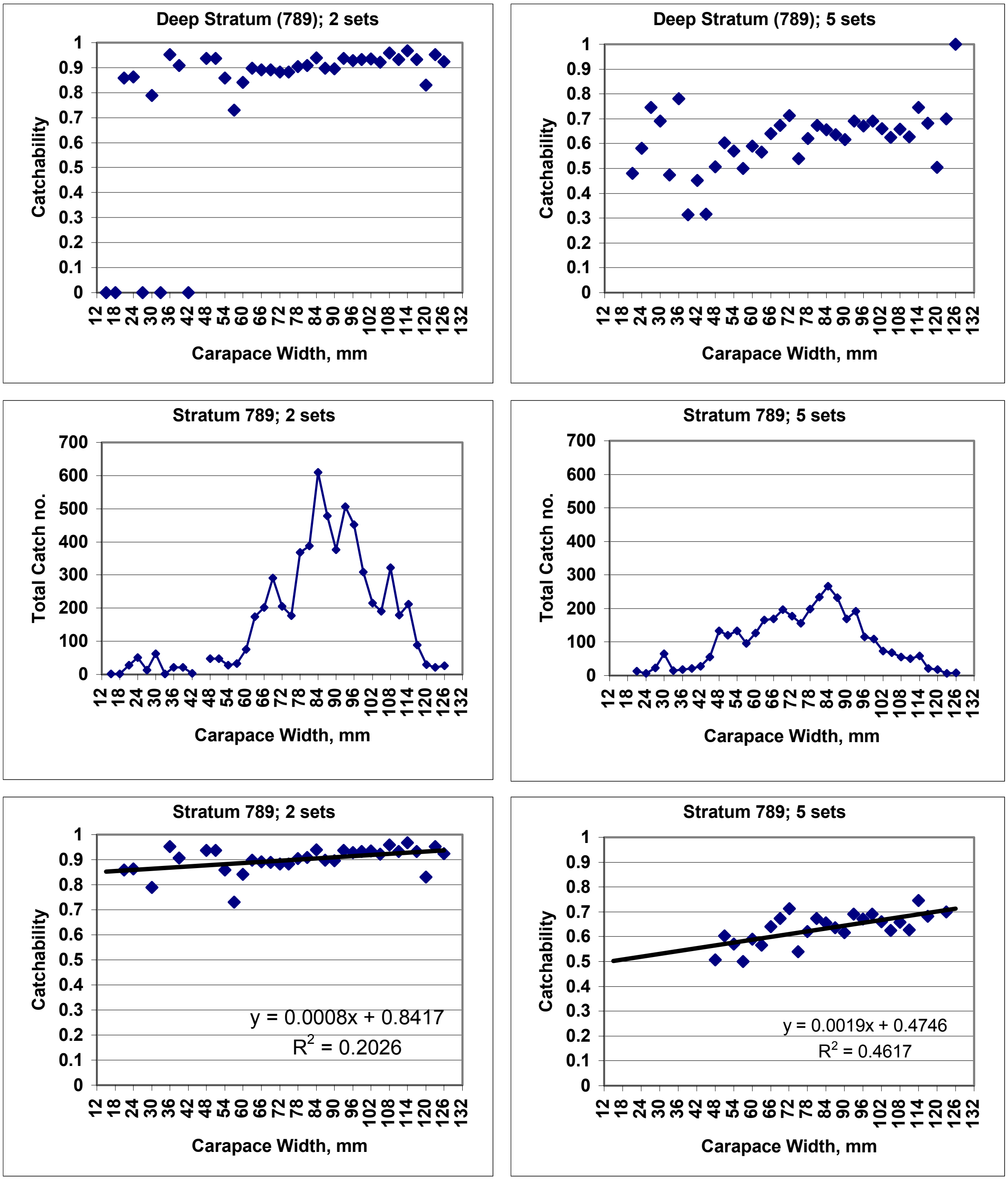

Fig. 3. Plots of catchability on carapace width (CW) using all data (top), CW composition of all males caught (middle), and plots with linear models overlain and outliers rejected describing the relationships of catchability with CW (bottom), for the deepest stratum, based on the two stations with highest catchability (left) and the remaining 5 stations in the deeper stratum, with smallest crabs not included in the modeling (right).

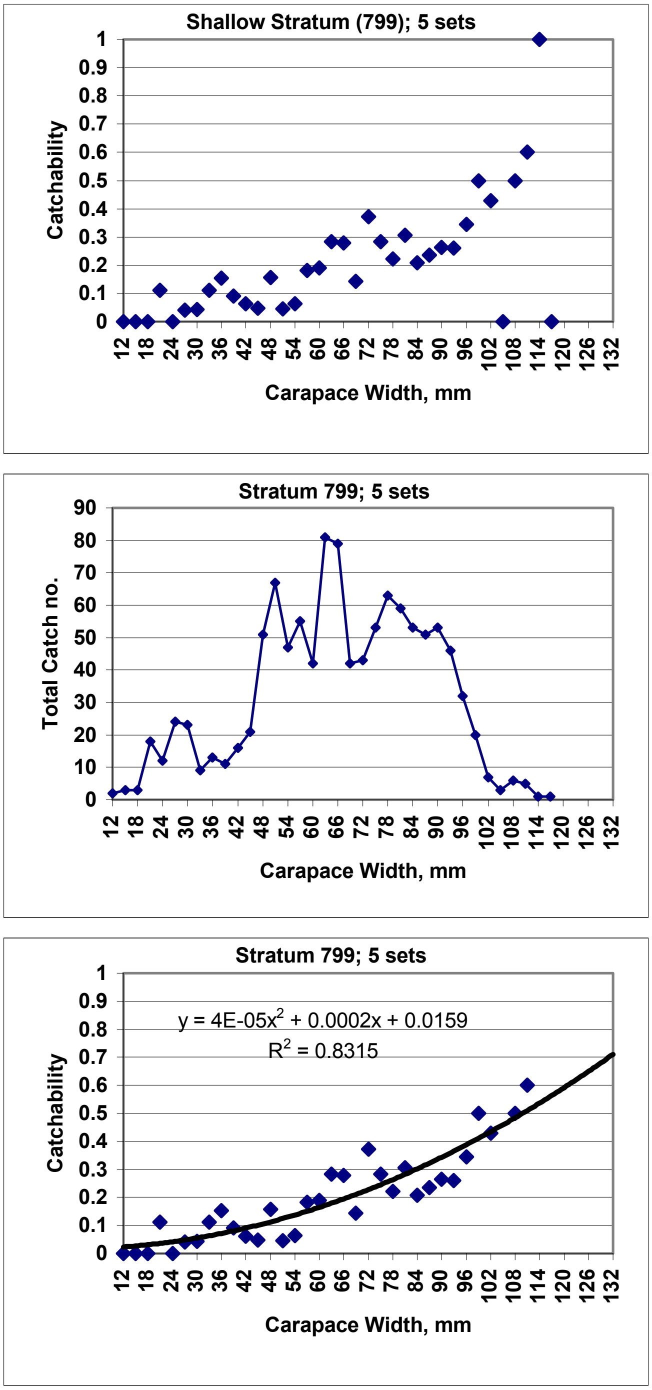

Fig. 4. Plot of catchability on carapace width (CW) using all data (top), CW composition of all males caught (middle), and plot with third order polynomial model overlain and outliers rejected describing the relationship of catchability with CW (bottom), for the shallower stratum.

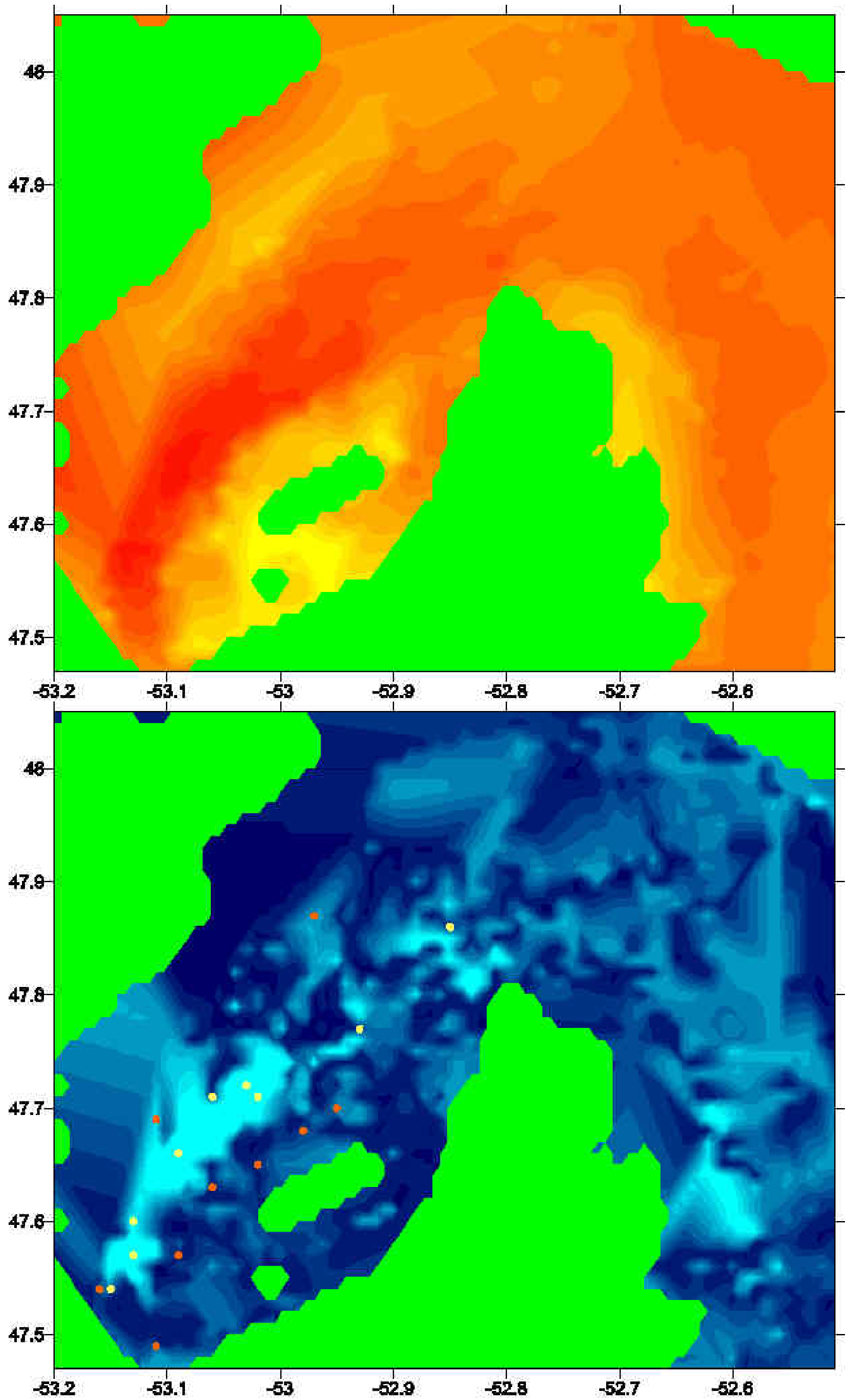

Fig. 5. Map of Conception Bay showing the distribution of depth (above; darker red represents greater depth) and of station locations in relation to substrate types (below; darker blue represents harder substrates).

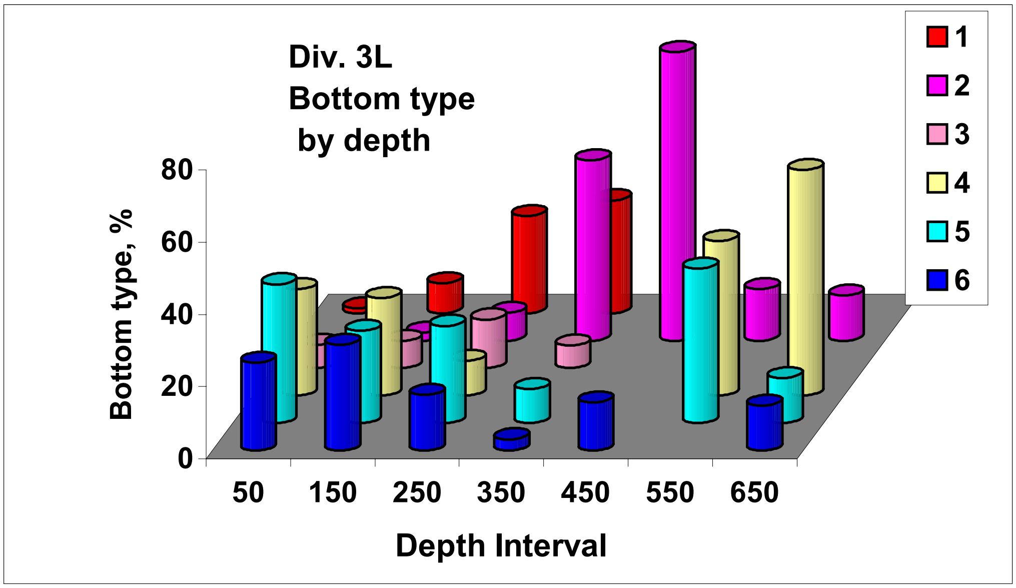

Fig. 6. Distribution of substrate type by depth from RoxAnn Seabed Classification System data for offshore Div. 3L (northern Grand Bank); bottom types range from dark red (softest and smoothest; in back) to dark blue (hardest and roughest; in front).