Section 5. Bottom Trawl Survey and Finfish Research in the South Shetland Islands; submitted by Christopher D. Jones (Leg III), Karl-Hermann Kock (Leg III), Sunhild Wilhelms (Leg III), David Ramm (Leg III), Julian Ashford (Leg III), Tom Near (Leg III), Jennifer H. Emery (Legs I, II & III), Nancy Gong (Legs II & III), Hauke Flores (Leg III), Alison R. Banks (Legs I, II & III) and Mark Prowse (Legs I, II & III).

5.1 Objectives: Commercial fishing for finfish in the South Shetland Island chain was conducted from 1978/79 through 1988/89. The main species fished or taken in this region were *Champsocephalus gunnari* and *Notothenia rossii* (Agnew and Nichol, 1996), as well as several bycatch species, including *Gobionotothen gibberifrons*, *Chaenocephalus aceratus*, and *Chionodraco rastrospinosus* (CCAMLR, 1990). Within two years after the fishery was developed, catches declined substantially. This lead CCAMLR eventually to impose a moratorium on taking finfish from the South Shetland Islands from 1989/90 to the present. Before the shelf areas can be re-opened to possible exploitation, it is essential to monitor the biomass of potentially fishable stocks, and to better understand the biology, ecology, and life history characteristics of the finfish species, as well as the impact of exploitation on the Antarctic ecosystem.

Before the closure of the fishery, there were several bottom trawl surveys of the Elephant Island region conducted by the Federal Republic of Germany (Kock, 1998) and one semipelagic trawl survey in 1987 conducted by Spain (Balguerias, 1987). The Spanish survey was also extended to the lower South Shetland Islands. Since the moratorium, there has been one German survey of the Elephant Island Region in the 1996/97 split year (Kock, 1998), and two AMLR bottom trawl surveys (including this one) of the entire South Shetland Islands (Jones *et al*., 1998). The AMLR program has expanded coverage of the southern Scotia Arc to include the South Orkney Islands (Jones *et al*., 2000; Kock *et al*., 2000), effectively examining the fishable shelf regions of the entire southern Scotia Arc region.

This bottom trawl survey was designed to provide baseline estimates of abundance, species composition, size composition, and demographic structure, and to collect information on the biology of finfish species within the 500m isobath of the South Shetlands Islands. In addition to trawling to determine levels of biomass of demersal finfish, we also conducted finfish diet studies, underway acoustic sampling of krill swarms and myctophid layers, and CTD's, and collected and characterized all benthic invertebrate by-catch, performed classification of the seabed types, and collected video and grab samples of seabed for substrate ground truthing. The overall objective was collection of data to conduct an ecosystem-based assessment of the biomass and distribution of Antarctic demersal fish within the 500m isobath of the South Shetland Islands.

5.2 Methods and Accomplishments:

Bottom Trawling

The fishing gear used was the "Hard Bottom Snapper Trawl" with vented V-Doors both manufactured by Net Systems, Inc. (Bainbridge Island, WA). A "Netsweep 325" net sonar

system (Ocean Systems Inc.) was used to record the net mensuration (height and width of the trawl mouth), as well as optimize the trawl interaction with the bottom. Diagrams of the net, doors, and rigging can be obtained from the AMLR program upon request.

Trawling operations were conducted aboard the R/V *Yuzhmorgeologiya* March 12, 2001 through March 31, 2001. The sampling strategy was based on a random depth stratified survey design, and stations were positioned to account for a wide geographic range. There were five designated depth strata: 50-100m, 100-200m, 200-300m, 300-400m and 400-500m. There were a total of 71 hauls completed (Figure 5.1) around the South Shetland Islands: 37 around Elephant Island (Table 5.1) and 34 around the lower South Shetlands Islands (Table 5.2). The numbers of hauls within the five depth strata were 11 (50-100m), 23 (100-200m), 16 (200-300m), 12 (300-400m), and 9 (400-500m). Allocation of hauls within depth strata were proportional to the known areas of seabed (Jones *et al*., 1999) and weighted by previous estimates of abundance in each stratum from the 1998 AMLR Survey of the South Shetland Islands (Jones *et al*., 1998). In all cases, a haul was taken only after initial acoustic reconnaissance verified that bottom conditions were suitable for trawling. The initial survey design called for one additional haul within the 400-500m depth range northwest of Snow Island in the far western lower South Shetlands. However, due to rough ocean conditions, this station was abandoned for safety reasons. At least two other stations were repositioned from this area to a more sheltered region west of Deception Island after suitable seabed within targeted depth strata was located. The realized locations of almost all hauls varied considerably from the initial planned coordinates due to sea, wind, bottom, and ice conditions. However, with the exception of one station, the planned survey design was completed successfully.

All hauls were conducted during daylight hours. The target time for a trawl was 30 minutes. Any haul less than 20 minutes was considered invalid, and discarded. Trawling started as soon as the footrope made contact with the bottom. Once contact with the bottom was made, position, time, ship speed, bearing, headrope depth, bottom depth, and net mensuration were recorded. Recordings were made every five minutes thereafter, for a total of seven observations for each haul. Supplementary data collected for each haul included ship course, air temperature, wind speed and direction, weather, cloud conditions, sea state, light and ice conditions. All haul and cruise specific information is stored in hardcopy format and in a computer database maintained by the U.S. AMLR Program.

Haul Processing

After a successful haul, the contents of the trawl were emptied onto the deck and transferred to a sorting table, where fish were identified, separated into species, and placed into individual species baskets. Organisms other than fish were processed separately (See Section 6 of this report "Invertebrate Bycatch From Benthic Trawling Around Elephant and South Shetland Islands, Antarctica"). Baskets were weighed to obtain total catch weights by species. Where catches of a single species were very large, a subsample of the catch was taken (see Sub-sampling Protocol below). In several cases, large yields of finfish were released live after the sub-sampling protocol.

There were two categories of catch processing. Category 1 included length (nearest cm below), sex, and gonad maturity stage. Lengths were measured as total length (length from tip of snout to end of caudal fin) for all species except myctophids, for which length was measured as standard length (length from tip of snout to end of caudal peduncle). Maturity was classified on a scale of 1 to 5 (immature, maturing virgin or resting, developing, gravid, spent) according to the method of Kock and Kellermann (1991). Category 2 processing included full biometric data including length, weight, sex, maturity, gonad (ovary or testis) weight, diet composition, eviscerated weight, and otoliths. All weights were measured as total fresh weight to the nearest gram.

An intensive diet study of 20 finfish species was conducted. Stomach contents information included whole stomach weight and stomach contents weight. A measure of the filling degree was taken according to a scale of 0-5 (empty, 25% full, 50% full, 75% full, 100% full, regurgitated). A measure of fullness was recorded according to a scale of 1-3 (fresh, moderately digested, fully digested). The relative volume of each species present within a stomach was recorded by assigning each dietary component a proportion from 0-10, with the total score for each stomach totaling 10. A total of 4,023 stomachs of 20 species was examined. The variability in diet was substantial for most species, and may be related to the depth strata, benthic and seafloor composition and geographic location of station. An additional 1,200 stomachs were preserved for transport to home laboratories for detailed analysis.

Otoliths were taken from 3,073 fish of 10 species for age and growth work to be undertaken at the Center for Quantitative Fisheries Ecology (CQFE) based at Old Dominion University (ODU) in Virginia. Collections were made for the following species: *Chaenocephalus aceratus* (462), *Champsocephalus gunnari* (696), *Chionodraco rastrospinosus* (418), *Dissostichus mawsoni* (60+), *Electrona antarctica* (128), *Gobionotothen gibberifrons* (405), *Gymnoscopelus nicholsi* (277), *Lepidonotothen squamifrons* (182), *Notothenia coriiceps* (277), and *N. rossii* (91). Otoliths will be used to estimate age and construct age-length keys, which will allow age-based models to be used in assessing the population biology and stock status of each species. Further collections have been made of hard parts from *C. aceratus* and *C. gunnari* to examine alternative calcified structures for their potential in estimating age. Hard parts collected were the three pairs of otoliths: the asterisci, lapilli, and sagittae; the pectoral and pelvic fin rays; the dorsal and anal fin spines; vertebrae; and opercula. Hard parts were also collected from 30 *D. mawsoni*. The best calcified structure for each species will be used to analyze the precision of repeated age estimates using an experimental design developed at the CQFE. This information will be used to assess the reliability of age estimates and capacity of the resulting age-length key to discriminate between age cohorts in age-based modeling.

Rare or unusual specimens/biological materials were preserved in buffered formalin or ethanol and packaged for transport to home laboratories. In addition to collection of *D. mawsoni* tissue samples for DNA analysis, we processed 348 fish of 28 species for systematic and phylogenetic studies at the University of California, Davis. A number of oocytes were also collected from running ripe individuals and their diameter was measured. Oocytes were counted and collected from the zoarcid *Pachycara brachycephalum*. Gonads of the channichthyid *Cryodraco antarcticus* were collected for a more detailed study at the Institute for Sea Fisheries laboratory

in Hamburg, Germany. The measurements of gonado-somatic index (GSI) (Kock, 1989) were collected from several species to describe the individual gonad stage.

Sub-sampling Protocol

Where yields of a species were too large to process in their entirety, sub-sampling was performed using randomized techniques for either Category 1 or Category 2 processing. When using a straightforward simple random sampling with each fish as an independent sampling unit was logistically impractical, we used full baskets of fish as primary sampling units (PSUs). Two forms of sampling strategies were then used: *cluster sampling*, where all fish within a basket were sampled, and *multi-stage sampling*, were only some of the fish within a basket were sampled at random. These strategies generate parameter estimates with reliable estimates of variance, which allow for statistical inferences to be made. Sampling effort was adjusted for each haul to allow sampling to be completed before the next haul was on deck.

The basic methodology was as follows: 1) Sorting by species was completed and all baskets (*i*) weighed. 2) The weighed baskets were treated as *i*PSUs. A minimum of two PSUs (baskets)/species were selected for sub-sampling using a random number table (Rohlf and Sokal, 1995). All fish within the selected PSU were processed, either for Category 1 data or Category 2 data. 3) Category 2 fish were selected from all fish in a PSU by drawing from a pack of shuffled cards. In most cases, we sampled a 25% proportion by selecting fish corresponding to drawn cards marked by hearts. Cards were used to sample smaller numbers of Category 2 fish using fish corresponding to royalty (23%), kings and queens (15%), or aces (7.6%). 4) Both baskets were weighed and recorded, and processing was completed.

5.3 Results and Tentative Conclusions:

Catches

A total of 7,238kg (17,581 individuals) of 44 fish species was processed from all hauls from Elephant Island (Table 5.3) and the lower South Shetlands Islands (Table 5.4). Species that were caught in substantial numbers, defined as >500kg or >500 individuals, included *Notothenia coriiceps*, *Gobionotothen gibberifrons*, *Champsocephalus gunnari*, *Chaenocephalus aceratus*, *Chionodraco rastrospinosus, Gymnoscopelus nicholsi,* and *Lepidonotothen larseni*. The greatest combined yields occurred at stations on the western and northwestern shelf of Elephant Island and north of King George Island within the 100-200m depth strata (Figure 5.2A). The highest diversity of finfish species occurred north and east of King George Island within the 300-400m depth strata (Figure 5.2B). The species with the greatest yield in weight was *Notothenia coriiceps* (2,296kg, 1,752 individuals), followed by *Gobionotothen gibberifrons* (2,128kg, 3,041 individuals) and *Champsocephalus gunnari* (778kg, 4,318 individuals). The greatest catch in numbers was *C. gunnari* followed by the myctophid *Gymnoscopelus nicholsi* (3,662 individuals) and *G. gibberifrons* (2,128kg, 3,041 individuals).

There was substantial variation in catches between stations. The average yield for a single haul was 102kg (σ=217), and 248 individual fish (σ=324). The greatest yield in weight for a single haul was 1,568kg (1,371 individuals) at Station 48 north of King George Island (Figure 5.2A).

This haul was dominated in weight by *Notothenia coriiceps* (98%). Other substantial yields were encountered northwest of Elephant Island at Station 20 (635kg, 655 individuals), in which 56% were *Gobionotothen gibberifrons* and 33% were *Chaenocephalus aceratus*, and west of Elephant Island at Station 4 (610kg, 1,126 individuals), 69% of which was comprised of *G. gibberifrons* and 17% were comprised of *C. aceratus*. Another notable catch occurred west of Elephant Island at Station 1, were 1,320 (143kg) juvenile *C. gunnari* were captured.

Although there were a total of 44 different species encountered, the number of species present in each haul (Figure 5.2B) ranged from 2 to 16, with an average of 9 species per haul. Figure 5.2B demonstrates substantial variability in species richness per haul around the South Shetland Islands, with a somewhat lower species diversity at the most nearshore stations. The most frequently encountered species was *C. aceratus*, which was found within catches at 61 of the 71 stations (86%). Other species encountered frequently were *G. gibberifrons* (83%), *C. gunnari* (76%), *C. rastrospinosus* (68%), *L. larseni* (64%), and *N. coriiceps* (58%). All other species occurred in less than 50% of hauls.

General Features of Finfish in the Southern Scotia Arc

Two ichthyofaunal elements overlap in the southern Scotia Arc region: the low-Antarctic (or peri- or lesser Antarctic) and the high-Antarctic fauna. Most finfish species within the 500m isobath of island groups in the southern Scotia Arc are nototheniids and channichthyids of low-Antarctic origin. This group makes up about 85% of the overall finfish biomass. The most dominant low-Antarctic species before commercial fishing commenced were *N. rossii*, *G. gibberifrons*, *L. squamifrons*, *C. gunnari*, *C. aceratus* and *Pseudochaenichthys georgianus*.

High-Antarctic species reach their northernmost limit of distribution in the southern Scotia Arc. High-Antarctic species are represented primarily by nototheniids, such as *Trematomus eulepidotus*, and channichthyids, such as *Cryodraco antarcticus*. They are more likely encountered in waters deeper than 250m. Members of the other two notothenioid families, Bathydraconidae (except *Parachaenichthys charcoti*) and Artedidraconidae are extremely rare, and are usually caught as single individuals. Other rare high-Antarctic species include the nototheniids *T. bernacchii*, *T. newnesi*, *T. pennellii* and *T. loennbergi*. The only high Antarctic species of the family Channichthyidae that is caught in substantial numbers is *C. rastrospinosus*. During this survey, we also encountered the rare channichthyid *Pagetopsis macropterus*.

Mesopelagic species, primarily *Gymnoscopelus nicholsi* and *Electrona antarctica* are more abundant in waters deeper than 350m. Other mesopelagic fish regularly encountered are *Paradiplospinus gracilis* and in deeper hauls below 400m *Gymnoscopelus braueri*. Other myctophids, such as *G. opisthopterus* and *Krefftichthys anderssoni* were only caught as single individuals.

Non-notothenioid species which are observed in some numbers are the three rajiid species: *Bathyraja eatonii*, *B. maccaini*, which grow to more than 100cm; and the small-sized *Bathyraja* sp. 2, which rarely exceeds 60cm in size. Zoarcids are mostly deep-water species. Only three species occur regularly in water shallower than 500m, and all were found to be much more abundant than in 1998. *Lycodichthys antarcticus* was only caught as individuals. However, the

other two species, *Pachycara brachycephalum* and *Ophthalmolycus amberensis*, occurred regularly.

Results - Finfish Species of Importance:

Champsocephalus gunnari

One of the most important finfish in the South Shetland Islands, and throughout the Scotia Sea, is the channichthyid *C. gunnari*, an active bentho-pelagic species. A total of 789kg (4,318 individuals) was captured from 54 stations (Tables 5.3 & 5.4), and the overall average standardized density was 252.3kg/nm^2 (F = 451.8). The majority of the *C. gunnari* catch (about 68%) occurred around Elephant Island, particularly in areas to the west and northwest (Figure 5.3A). In both Elephant Island and the lower South Shetlands Islands, there appears to be a general spatial increase in abundance in westerly stations, particularly along the South Shetlands. The highest average densities occur within the 100-200m depth strata of both areas (Tables 5.3 & 5.4). The large catches west of Elephant Island were mainly due to concentrations of juvenile fish. The size distribution ranged from 12 to 54cm, with strong overall modes at 25cm, 37cm, and 44cm (Figure 5.4A). There appears to be an additional mode in the lower South Shetlands Islands at about 28cm, and a substantially greater proportion of adult fish. This pattern was also observed during the 1998 AMLR survey of the South Shetland Islands, suggesting that a higher proportion of juvenile *C. gunnari* relative to mature individuals are more likely to be found west of Elephant Island during the austral summer.

Most fish (50%) were juveniles (maturity stage 1) with 21%, 29%, and .5% observed at maturity stages 2, 3, and 5, respectively. About 54% of the catch was female. *C. gunnari* appears to spawn over a more extended period of time than other channichthyids. The different stages of gonadal development expressed by a large range of GSIs observed in different parts of the shelf point at an extended period of spawning of about 3 months. The first spent fish were observed in the catch in the beginning of the survey. However, no fish in spawning condition were observed during this survey (Table 5.5). Spawning appears to be less synchronized than in other channichthyids and occurs over a longer period of time in *C. gunnari*.

An intensified diet composition sampling effort was conducted for *C. gunnari* to investigate potential differences in food composition and the amount in various parts of the shelf. A total of 1,072 stomachs from *C. gunnari* was analyzed. Of these stomachs, 17.5% were empty. Whenever sample sizes of the species were large enough, 40 stomachs were frozen and the necessary ancillary information from the individual fish (length to the cm below, total and eviscerated weight, sex, maturity stage, gonad weight, stomach fullness and stomach fresh weight) was collected. All stomachs containing food were frozen from catches containing less than 40 individuals. A total of 834 stomachs contained food and were frozen for further studies.

The stomach contents of 238 fish, randomly sampled of the catch (See "Sub-sampling Protocol" above) were examined at sea. Of the fish with full or partially full stomachs, the composition of 99% of stomach contents consisted solely of krill (*Euphausia superba*), and 1% consisted of myctophid fish and unidentified species (Figure 5.5). However, the amount of food taken and

the degree of digestion varied considerably between stations and even within a station. Stomach content weight varied from < 1 to 10 % of the body weight.

Chaenocephalus aceratus

The channichthyid *C. aceratus*, a sluggish sedentary species, was the most frequently encountered finfish species. A total of 738kg (1,091 individuals) was captured from 61 stations (Tables 5.3 & 5.4), and the overall average standardized density was 785.4kg/nm^2 (F = 2,115.6). The overall distribution of biomass was similar to that of *C. gunnari*, where the majority of the *C. aceratus* catch (about 72%) occurred around Elephant Island, particularly in areas to the west and northwest (Figure 5.3B). Catches were made from all strata, with the greatest average densities occurring within the 100-200m depth strata of both areas (Tables 5.3 & 5.4). The size distribution of *C. aceratus* was among the greatest of any species captured, ranging from 10 to 71cm. Well-defined modes appear at 25cm, 33cm, 48cm, and 60cm (Figure 5.4B), with substantially more fish in the 2nd modes in the South Shetland Islands and greater numbers of larger size classes around Elephant Island.

Fish were found at all stages of maturity. Most fish (58%) were juveniles (maturity stage 1) with 23%, 15%, 0.6%, and 3% observed at maturity stages 2, 3, 4 and 5, respectively. Sexes were equally represented in the catch. Spawning starts in March (Table 5.5). We found a small number of spent females from mid-March onwards. The similar developmental stage of the ovaries suggested that maturation for *C. aceratus* is more synchronized than *C. gunnari*. Consequently the spawning time is shorter than in *C. gunnari* and is unlikely to extend past 6-8 weeks. GSIs were mostly >14 with some females close to spawning with a GSI of > 23. Oocyte diameter was 4.4-4.7mm for *C aceratus*.

An intensified stomach composition sampling effort of *C. aceratus* was conducted. A total of 692 stomachs from *C. aceratus* was analyzed (Figure 5.5). Because regurgitation of the stomach contents often occurred, a total of 150 stomachs of *C. aceratus* containing food were examined. *C. aceratus* change their diet when they reach sizes of 25-30cm. Small fish fed on krill, and to a lesser extent on fish (Figure 5.5). Larger *C. aceratus* lived entirely on other fish.

Chionodraco rastrospinosus

The channichthyid *C. rastrospinosus* is the only true high Antarctic species that appears regularly in catches. A total of 503kg (1,133 individuals) was captured from 48 stations (Tables 5.3 & 5.4), and the overall average standardized density was 540.2kg/nm^2 (F = 1,238.7). The majority of catches occurred north of King George Island and the most offshore stations west of Elephant Island (Figure 5.3C). Although we have observed in the past that *C. rastrospinosus* tend to favor depths greater than 300 meters, the highest average densities were encountered within the 200-300m depth strata of both areas (Tables 5.3 & 5.4). The size distribution of *C. rastrospinosus* ranged from 21 to 48cm. Well-defined modes appeared at 31cm and 40cm (Figure 5.4C), with greater numbers of large fish encountered in the lower South Shetland Islands.

Fish were found at all stages of maturity. Most fish (52%) were juveniles, with 20%, 26%, 0.8%, and 1% observed at maturity stages 2, 3, 4 and 5, respectively. Most fish (57%) were males. The development of the ovaries was slightly more advanced in the South Shetland Islands than around Elephant Island. This suggests a slightly earlier start of the spawning season (about 14 days) in the South Shetland Islands. The synchronized development of most ovaries suggests a comparatively short spawning period of 4-6 weeks. GSIs in most females were 16-21 around Elephant Island and 18-24 in the South Shetland Islands. GSIs in some spawning fish were 24-28 (Table 5.5). Egg diameter at spawning was 4.5-5.0mm.

A total of 436 stomachs from *C. rastrospinosus* was analyzed. All stomachs were filled to at least 25% capacity. The average diet composition consisted mainly of krill (84%; Figure 5.5). In addition, their diet consisted of fish (12%), amphipods, octopus, salps, and unidentified organisms (E=6%).

Dissostichus mawsoni

The nototheniid *D. mawsoni* is the most likely fish species to be targeted in any future fishing operations, and thus warranted special attention during our surveys. A total of 40kg (66 individuals) was captured from 32 stations (Table 5.3 & 5.4), and the overall average standardized density was 41.8kg/nm^2 (F = 67.5). Although this is a small number relative to the other species captured, this represents about twice as much as was captured during the 1998 survey. Fish were relatively evenly distributed across the entire island chain (Figure 5.3D). Although the sample sizes were small, catches were observed at all strata, with the greatest average densities occurring within the 200-300m depth strata of both areas (Table 5.3 & 5.4). The size distribution ranged from 13 to 60cm. Although there are fairly well-defined modes (Figure 5.4D), the sample sizes were small.

Most fish (97%) were juveniles, with the other 3% at the maturing virgin stage, with no other information available regarding the spawning. Sexes were equally represented in the catch. Stomach contents were examined from all fish. About 18% of these fish had empty stomachs. The composition of the diet for those fish with stomach contents consisted mostly of fish (68%), and krill (32%) and an occasional amphipod (Figure 5.5). There was no apparent shift in diet composition with size.

Gobionotothen gibberifrons

The nototheniid *G. gibberifrons* is the most abundant finfish in the South Shetlands Islands, as well as the second most frequently encountered. A total of 2,128kg (3,041 individuals) was captured from 59 stations (Tables 5.3 & 5.4), and the overall average standardized density was 2,222.2kg/nm^2 (F = 5,696.5). The majority of catches occurred west and northwest of Elephant Island and north of King George Island (Figure 5.3E). Catches were observed at all strata, with the greatest average densities occurring between 100-300 meters (Tables 5.3 & 5.4). The size distribution ranged from 22 to 50cm, with a single mode appearing at around 38cm for combined area length distributions (Figure 5.4E). However, when broken down by area, there were two clearly defined modes, one at 36cm at the lower South Shetlands Islands and the other at 39cm around Elephant Island. An almost identical pattern was observed during the 1998 AMLR

survey, and this suggested that a higher proportion of juvenile *G. gibberifrons* are likely to be found in the lower South Shetlands Islands, which is the opposite of what we observed in the case of *C. gunnari*.

Fish were either maturing virgin or had developing gonads. Most fish (61%) were stage 2, and stage 1 (31%), with 7% immature, with slightly more females (55%) than males. Most fish appear to mature at 33-36cm lengths. Testes have a similar size as ovaries. Low GSIs of less than 8 in most individuals confirmed earlier observations around Elephant Island (Kock, 1989) and in the South Orkney Islands in 1999 that the species is a winter spawner (July-August; Table 5.5).

This species demonstrated the highest degree of variability in diet composition of all finfish encountered. A total of 411 stomachs from *G. gibberifrons* was analyzed. Most stomachs (96%) were at least 25% full. *G. gibberifrons* is primarily a benthic browser, and thus has a varied diet (Figure 5.5). Due to a large content of partially digested benthic invertebrate species, about 30% of the average diet was unidentifiable to species group. The greatest species groups that were identified were amphipods (17%), followed by ophiroids (12%), polychaetes (9.6%), salps (8.5%), krill (7.3%), isopods (7.2%), echinoderms (3.2%), and combined fish, pycnogonids, octopus, mysids, siphonophores, and fish eggs (E=5%).

Lepidonotothen larseni

The nototheniid *L. larseni* is small and not commercially important, but is relatively abundant and encountered quite often in the southern Scotia Sea. A total of 29kg (585 individuals) was captured from 46 stations (Tables 5.3 & 5.4), and the overall average standardized density was 31.9kg/nm^2 (F = 44.4). The majority of catches occurred northwest of Elephant Island in deep stations and north of King George Island (Figure 5.F). This species was encountered in greatest numbers between 200 and 400 meters (Tables 5.3 & 5.4). The size distribution of *L. larseni* ranged from 7 to 22cm, with a well-defined mode at 18 cm, and a smaller mode at 14cm (Figure 5.4F). There was an almost identical size distribution in both areas.

Most fish (72%) were females that had started the process of gonad maturation. The majority of fish (48%) were mature stage 3, with 21% immature and 25% developing virgin. However, the still low GSIs (<8) confirmed earlier observations (Kock, 1989) that the species is a winter spawner (July-August; Table 5.5).

A total of 102 stomachs from *L. larseni* was analyzed. Most stomachs were (78%) at least 25% full. The average diet was composed of krill (66%), salps (9%), amphipods (7%), and unidentified benthic invertebrate organisms (E=18%) (Figure 5.5).

Lepidonotothen nudifrons

The nototheniid *L. nudifrons* is a small species which rarely exceeds 21cm in size, not commercially important, but potentially important in the Antarctic finfish community. A total of 13.8kg (325 individuals) was captured from 32 stations (Tables 5.3 & 5.4), and the overall average standardized density was 15.6kg/nm^2 (F = 47.7). Two hot spots of *L. nudifrons* were

encountered: one south of the eastern tip of Elephant Islands and one north of Snow Island in the western South Shetland Islands (Figure 5.G). This species has a shallow water distribution, with the greatest densities between 50 and 100 meters (Tables 5.3 & 5.4). The size distribution of *L. nudifrons* ranged from 7 to 20cm, with a well-defined mode at 15cm, and similar size composition in both areas.

Mostly female (67%) sexually mature individuals were captured. Gonads were well advanced in development with GSIs of 18-22 in most females. The smallest females observed with developing gonads were 11cm long. Spawning is likely to start in mid-April. The synchronized development of the gonads suggests a comparatively short spawning season of 4-6 weeks (Table 5.5).

A total of 43 stomachs from *L. nudifrons* was analyzed. Most stomachs (about 80%) were at least 25% full. This species has a varied diet (Figure 5.5). Due to a large proportion of partially digested benthic invertebrate species, about 40% of the average diet was unidentifiable to species. The largest groups identified were krill (33%), followed by amphipods (19%), isopods (5.3%), and polychaetes (2.6%).

Lepidonotothen squamifrons

The deep-water nototheniid *L. squamifrons* has been commercially exploited in other Antarctic island groups, and is abundant in other parts of the southern Scotia Arc, such as the South Orkney Islands. A total of 132kg (410 individuals) was captured from 23 stations (Tables 5.3 & 5.4), and the overall average standardized density was 132.4kg/nm^2 (F = 407.2). The majority of catches occurred in the most offshore stations to the north and west of Elephant Island and north of King George Island (Figure 5.3H). The highest average densities were encountered between 400-500 meters, although there were some catches as well in the 300-400 meter strata (Tables 5.3 & 5.4). The size distribution of *L. squamifrons* ranged from 14 to 47cm. Most of the size class modes were mixed (Figure 5.4H), with a similar size composition between areas.

Fish were found at four stages of maturity, with 61% juveniles, and 22%, 8%, and 7% observed at maturity stages 2, 3, and 5, respectively. Most fish (60%) were females. The species was in the middle of the spawning season (Table 5.5). Spawning may occur in waters deeper than 500m, which were not covered by our survey.

A total of 185 stomachs from *L. squamifrons* was analyzed for diet composition. About 78% of these fish had stomachs that were at least 25% full. Like other species in the genus *Lepidonotothen*, the diet was complex, but was comprised mainly of krill (66%), unidentified benthic invertebrates (18%), salps (9%), amphipods (7%), polychaetes, and echinoderms (E<2%) (Figure 5.5).

Notothenia coriiceps

The nototheniid *N. coriiceps* is the second most abundant finfish species in the South Shetlands Islands, after *G. gibberifrons*, and was the species that yielded the greatest catch in weight in this survey. A total of 2,296kg (1,752 individuals) was captured from 41 stations (Tables 5.3 & 5.4),

and the overall average standardized density was 2,739kg/nm^2 (F = 16,458). Similar to the 1998 AMLR survey, we encountered a very large pre-spawning aggregation north of King George Island (Figure 5.3I). This species has a shallow water distribution, with greatest average densities between 100 and 200 meters (Tables 5.3 & 5.4). The size distribution ranged from 25 to 58cm, with a single mode appearing at around 42cm for combined area length distributions (Figure 5.4I). The size compositions were similar between areas.

Almost all individuals (95%) caught were stage 3 sexually mature; the remaining at stage 2 (though close to 3). There were slightly more males (58%) than females. Maturation of most gonads appears to be synchronized, suggesting that the species reproduces over a comparatively short spawning season. This confirms earlier observations by Kock (1989) in the Elephant Island region in May-June 1986 who found that more than 80% of the females spawned within a 4-week period between mid-May and mid-June. GSIs of mostly 10-14 indicate that *N. coriiceps* spawn in 6-8 weeks time (Table 5.5).

This species demonstrated a surprising degree of variability in diet composition. A total of 296 stomachs from *C. coriiceps* was analyzed. Most stomachs (81%) were at least 25% full. The average diet was comprised of krill (44%), fish (28%), unidentified benthic invertebrates (9%), amphipods (8%), salps (5%), isopods, octopus, mysids, ophiroids, pycnogonids, polychaetes, and eggs (E=5.3%) (Figure 5.5).

Notothenia rossii

The nototheniid *N. rossii* was the primary target species in this area in the late 1970's fishery, and the recovery of this species is being closely monitored. A total of 129kg (118 individuals) was captured from 32 stations (Tables 5.3 & 5.4), and the overall average standardized density was 139.8kg/nm^2 (F = 345.2). Although these are still relatively small numbers, these yields were about three times as much as that captured during the 1998 AMLR survey. The majority of catches occurred north of King George Island and at stations northwest of Elephant Island (Figure 5.3J). This species was captured in all depth strata, with the highest average densities encountered within 200-400 meters of both areas (Tables 5.3 & 5.4). The size distribution ranged from 20 to 65cm, with no well defined length modes (Figure 5.4J). Several very large specimens of *N. rossii* were encountered in the lower South Shetlands Islands.

Fish were found at all stages of maturity, with the majority of fish (48%) at maturing virgin or resting stage (stage 2), and 30%, 19%, 1%, and 1% observed at maturity stages 1, 3, 4 and 5, respectively. Sexes were equally represented in the catch. Most individuals in the 30-50cm length range were apparently recruiting to the adult stock. Ovaries were still largely in the juvenile stage while most testes were in an early stage of development, indicating that males mature at a smaller size than females. The early stage of development of the testes suggests that these individuals would not spawn this year. The comparatively few developing ovaries were well advanced (GSI: 14-17 in females, 10-15 in males). Spawning was likely to start in about 4 weeks after these samples were taken (Table 5.5).

A total of 101 stomachs from *N. rossii* was analyzed for diet composition. About 80% of these stomachs were at least 25% full. The average diet composition was similar to that of *N.*

coriiceps, though slightly less diverse. Their diet consisted mainly of krill (60%), fish (20%), unidentified benthic invertebrates (6%), salps (3%), isopods, and, mysids (E=2%) (Figure 5.5).

Parachaenichthys charcoti

P. charcoti was the only species of the family Bathydraconidae caught in relatively substantial numbers. There has been very little information published on this species, particularly in terms of their diet. Thus, we took the opportunity to conduct intensified sampling to better understand this important bathydraconid species. A total of 7.4kg (112 individuals) was captured from 30 stations (Tables 5.3 & 5.4), and the overall average standardized density was 8.3kg/nm^2 (F = 15.7). The majority of catches occurred at shallow water stations to the west of Elephant Island, north of King George Island and Nelson Island (Figure 5.3K). This species was encountered in greatest numbers between 50 and 100 meters, with fewer numbers in deeper strata (Tables 5.3 & 5.4). The size distribution of *P. charcoti* ranged from 13 to 40cm, with a well-defined mode at 23-25cm and similar size composition in both areas (Figure 5.4K). Sexes were equally represented in the catches. Most fish (90%) were immature (stage 1), and with the exception of the other 10% at stage 2, gonads showed little indication of development, suggesting that the species spawns in the austral winter.

An intensive investigation of stomach contents and diet composition was performed for *P. charcoti*. A total of 85 out of 112 stomachs were processed. The majority of the diet composition of all stomachs consisted of mysids (55.8%), *Euphausia superba* (15.8%), unknown digested material (9.4%), amphipods (9.1%), fish (6.4%), and other crustaceans, isopods, tubeworms, and sponges (3.5%). The index of relative importance (Karpov and Caillet, 1979) indicated that mysids were the major prey item found in the stomachs of *P. charcoti*. Unknown digested material was found more often than *E. superba*, even though *E. superba* had comprised a greater percent composition than unknown digested material. The relative importance from greater to least prey items found in *P. charcoti* stomachs are unknown digested material, *E. superba*, fish, amphipods, tubeworms, other crustaceans, *Serolis* spp., and sponges. These preliminary findings disputed those of Targett (1981) and Gon and Heemstra (1990), who characterize fish the primary prey item of *P. charcoti*, based on a single specimen.

Pseudochaenichthys georgianus

A total of 141kg (169 individuals) of the channichthyid *P. georgianus* was captured from 24 stations (Tables 5.3 & 5.4). The majority of catches occurred at stations off Nelson, Greenwich, and Livingston Islands and northwest of Elephant Island (Figure 5.3L). Fish were encountered in all strata, with the highest average densities between 50-300 meters (Tables 5.3 & 5.4), and the overall average standardized density was 148kg/nm^2 (F = 312.1). The size distribution of *P. georgianus* ranged from 19 to 59cm. There were clear modes at 36 and 45cm, and a higher proportion of larger animals were captured off Elephant Island (Figure 5.4L).

Fish were found at three stages of maturity. Most fish (39%) were juveniles, with 24%, and 29% observed at maturity stages 2 and 3, respectively. Sexes were equally represented in the catch. *P. georgianus* spawns in April-May at South Georgia (Kock and Kellermann, 1991). However,

the low GSIs of <8 found in most individuals suggested that spawning occurs later further to the south and is unlikely to commence before June.

A total of 71 stomachs from *P. georgianus* was analyzed for diet composition. However, only about half had any stomach contents. The average diet was comprised mainly of fish (71%), krill (28%) and a small fraction of unidentified material (1.48%) (Figure 5.5).

Electrona antarctica* and *Gymnoscopelus nicholsi

These two species of mesopelagic myctophids are captured opportunistically during our surveys. Because they are likely the most important prey item after krill for several species of finfish, as well as many higher order birds and mammals, they are one of the most important finfish species in terms of the Antarctic ecosystem. A total of 4kg (265 individuals) of *E. antarctica* were captured from 15 stations and a total of 124kg (3,662 individuals) of *G. nicholsi* were captured from 23 stations. The majority of catches occurred at offshore stations north of Elephant Island for *E. antarctica* (Figure 5.3M) and north of Livingston Island for *G. nicholsi* (Figure 5.3N). While *G. nicholsi* was captured at all depth strata, the majority of both species was encountered in waters deeper than 300 meters (Tables 5.3 & 5.4). The size distribution of *E. antarctica* ranged from 69 and 114mm, with no well-defined length modes (Figure 5.4M). The length range for the larger, more abundant *G. nicholsi* was 118 to 175mm (Figure 5.4N), with large specimens encountered in the lower South Shetlands Islands.

Maturity stages were different for the two species. *E. antarctica* were in three stages of maturity, with most at maturing virgin or resting stage (stage 2), a limited number observed at maturity stages 1 and 3. *G. nicholsi* were almost all immature stage 1, with a small fraction observed at stage 2.

A total of 139 stomachs from *E. antarctica* and 340 stomachs from *G. nicholsi* were analyzed for diet composition. About 45% of *E. antarctica* and 80% of *G. nicholsi* stomachs were at least 25% full. The diet of both species consists primarily of krill (Figure 5.5), along with a small number of unidentified species, as well as amphipods.

Notes on Other Species

Several other species were captured in smaller numbers and were processed using the same sampling protocols, including analysis of diet composition (Figure 5.5), as the above species. At least eight species in the genus *Trematomus* were captured, all in small numbers. The most abundant was *Trematomus eulepidotus*. We captured about 7.6kg (26 individuals) from 10 stations, mostly around Elephant Islands between 300 and 400 meters. We examined the diet of 17 of these individuals, 11 of which had some contents in the stomach. Their diet consisted mainly of isopods (55%), and to a lesser extent fish (20%), and krill (18%) (Figure 5.5). This contradicts the findings of Tarverdiyeva and Pinskaya (1980) who found that *T. eulepidotus* fed mainly on krill, with no isopods as part of their diet in the South Shetland Islands. Most individuals were sexually mature and close to spawning. Spawning probably occurs in April-May. The species exhibits a sexual dimorphism in size in that females grow about 7cm larger than males. All individuals larger than 27cm were females. GSIs were 16-20.

We also captured several interesting specimens of the high Antarctic channichthyid *Cryodraco antarcticus* (48kg, 77 individuals from 20 stations). *C. antarcticus* is similar in size and morphology to *C. aceratus* and appears to replace *C. aceratus* in deeper water. Our survey only covered the upper part of the depth range of the species, which extends to 800m or beyond. A total of 62 stomachs from was analyzed, although only 21 fish had some stomach contents. The average composition consisted mainly of fish (80%), as well as krill (10%), and mysids (10%) (Figure 5.5). The species exhibits the same sexual dimorphism in size as *C. aceratus* in that females grow 15-18cm larger than males. Spawning appears to start in March as the first spent individuals were found. GSIs were 10-18. No females in spawning condition were caught. The very few mature males observed had GSIs of 6-7. Ovaries were preserved to estimate absolute and relative fecundity.

In addition, we captured several interesting specimens of the zoarcid *Pachycara brachycephalum* (5.8kg; 69 individuals from 17 stations). A total of 6 stomachs was analyzed for diet composition, half of which had some stomach contents. The diet composition for these specimens consisted of krill (50%), and amphipods (50%). Only one of the two ovaries is functional in zoarcids. We were able to collect four females of 26 to 32cm length with running ripe oocytes. Absolute fecundity was low and varied between 52 and 63 eggs with oocyte diameter greater than 6mm. The low number of eggs and the comparatively long incubation period suggested that eggs are either deposited in well-protected locations under stones or are guarded by either the male or female.

Antarctic Finfish Habitat Characterization

The seafloor of the shelf areas around the South Shetland Islands can include such features as banks, seamounts, plateaus, and submarine canyons. These are *megahabitat* features (Greene *et al*., 1999) and can be identified in bathymetric maps such as those presented by Jones *et al*. (1999). These features may provide very broad indicators of finfish distribution, such as the probability of presence of high-Antarctic vs. low-Antarctic fauna as a function of depth. To examine the role of habitat on similar fish assemblages it is necessary to examine smaller scale *mesohabitat* features (Auster, 1998). Mesohabitats are features that have a size from tens of meters to a kilometer (Greene *et al*., 1999), and the complexity of these habitats on Antarctic shelf areas can be influenced by a number of factors, including current regimes, proximity to landmass and glacial outflow, physical disturbance resulting from iceberg scouring, and impacts from fishing gear.

To determine the composition of the seafloor and available habitat for finfish, an acoustic digital discrimination and classification system was used. The seabed classes from the acoustic analysis were ground-truthed by means of a video system on a towed body (NEPTUN), and camera mounted grab sampler. A total of twelve successful bottom grab samples and seven Neptune tows were completed. The details of seabed classification and habitat characterization are presented in Section 3, "Bioacoustic Survey" in this report.

Mesohabitat features identified around the South Shetland Islands included areas of mud (silt and ooze), sand, gravel, pebble, cobble, boulder, bedrock and lava. We also found areas rich in

Antarctic invertebrate epifauna, which among other things, may provide Antarctic fish with structures for egg laying, settling and predator avoidance (Gutt and Ekau, 1996). In numerous instances, we observed fish in close proximity to sponges and other benthic invertebrate epifauna. Figure 5.6A shows a large colony of sponges with a fish (likely *C. gunnari*) very near the base of the structure. This behavior was observed with fish near very small benthic epifauna as well (Figure 5.6B). Given the proclivity of finfish to associate with structures on the seabed, our large scale habitat information will give valuable insight into the distribution and demographics of demersal finfish species, as well as potentially introducing alternative approaches to stratify surveys or post-stratify random survey designs prior to quantitative biomass modeling using habitat types as stratification criteria. At present, the relationship between Antarctic mesohabitats and finfish distribution and abundance requires considerable analysis, and any conclusions at this point would be premature. However, habitat information was collected from two areas that were distinctly different in finfish inventory and composition in the South Shetland Islands.

Low Diversity Habitat

The area west of Elephant Island around station 17 (Figure 5.1; Table 5.1) has among the lowest finfish density and diversity in the island chain (Figures 5.2A & 5.2B). This area yielded a total of only 12kg of three species of fish, *C. gunnari* (15), *C. aceratus* (3), and *C. coriiceps* (4). The acoustic seabed characterization of this transect indicated a statistically significant seabed class, and we conducted both video and grab sampling of this area for ground truthing (Figure 5.7). We confirmed that this area showed little structural diversity, and was composed primarily of bedrock (96%) with a thin layer of sand (.06-2mm grain size), gravel (2-4mm), and pebbles (4-64mm) and few other seabed features (Figure 5.7A-C). The development of benthic invertebrate fauna was among the lowest of any stations around Elephant Island. The invertebrate fauna was dominated by Asteroidea, which provides no usable structure for demersal fish. Interestingly, we found that krill were abundant in this region, particularly close to the bottom. Large numbers of krill were observed in the video right at the substrate (Figure 5.7A) and covering sporadic boulders (Figure 5.7D), suggesting that the substantial presence of prey does not necessarily indicate the potential for finfish presence. The krill that were observed were involuntarily carried by a strong current, which likely was responsible for the lack of fine silt settling in this region. Whether this current is a permanent hydrographic feature of this region requires further study.

High Diversity Habitat

The fishable grounds north of King George Island are interesting for several reasons. In addition to grounds that contain the highest densities of several species, this region also has areas of substantial finfish diversity. The seabed around Station 48 is an example of a high biomass, high diversity region (Figure 5.1; Table 5.1). This was the station where a large pre-spawning aggregation of *N. coriiceps*, as well as nine other species were encountered. The acoustic seabed characterization of the station 48 transect indicated several mixed significant seabed classes, with mostly (71%) dense structured mud/clay (grain size <0.06mm) and bedrock layered with sand and sediments (.06-2mm grain size) with wave-like structures. We conducted a video tow of this area for ground truthing these mixed areas (Figure 5.8). Figure 5.8A shows the very rich benthic

epifauna community that characterized the seafloor. The benthic invertebrate fauna encountered in this area was dominated by species in the phylum Porifera, which suggests that this substrate is more conducive to richer benthic development than the low diversity area dominated by sea stars described in the previous paragraph. The area also was characterized by "structured" mud and outcroppings and increased diversity of the seabed (Figure 5.8B). These mixed seabed classes, along with the rich epifauna, may provide a more optimal location for the *N. coriiceps* prespawning aggregations (visible in Figures 5.8C & 5.8D), which was also observed in this area during the 1998 AMLR fish survey.

5.4 Disposition of Data: All data collected were documented on hardcopy datasheets and entered into an MS-ACCESS computer database. The U.S. AMLR program maintains these hardcopies and computer databases.

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Table 5.1. Station and catch information for the 2001 AMLR finfish survey of the South Shetland Islands: Elephant Island stations.

Station	Region	Latitude	Longitude	Strata	Mean Depth	Number of Species	Total Catch (Kg)	Total Number
1	Elephant Island	61º 17.330’	55º 42.735’	2	143	11	182.393	1371
2	Elephant Island	61º 15.030’	55º 36.940’	1	80	8	11.795	33
3	Elephant Island	61º 11.505’	55º 41.410’	1	84	7	5.915	23
4	Elephant Island	61º 13.850’	55º 53.150’	2	137	8	609.901	1126
5	Elephant Island	61º 17.455’	56º 04.735’	3	285	9	50.491	164
6	Elephant Island	61º 21.885’	56º 01.735’	4	337	7	24.902	86
8	Elephant Island	61º 16.340’	56º 29.000’	5	416	10	59.607	267
9	Elephant Island	61º 09.200’	56º 13.355’	5	467	8	11.416	44
10	Elephant Island	61º 09.080’	56º 04.530’	2	156	4	46.854	174
11	Elephant Island	61º 10.435’	55º 54.355’	2	112	5	36.45	41
12	Elephant Island	61º 04.920’	56º 02.615’	3	232	5	17.312	27
13	Elephant Island	61º 03.260’	55º 43.280’	1	93	7	23.227	120
14	Elephant Island	61º 03.645’	55º 53.485’	2	143	4	110.929	327
15	Elephant Island	61º 00.975’	55º 58.470’	4	314	10	34.569	89
16	Elephant Island	60º 58.030’	55º 50.970’	2	157	9	416.865	1189
17	Elephant Island	60º 59.145’	55º 40.475’	1	58	3	12.584	22
18	Elephant Island	61º 06.430’	55º 42.705’	1	59	4	1.88	7
19	Elephant Island	60º 53.780’	55º 38.040’	2	141.6	10	101.407	129
20	Elephant Island	60º 53.690’	55º 42.790’	2	173	7	635.119	655

21	Elephant Island	60º 50.525’	55º 42.590’	3	267	5	19.337	26
22	Elephant Island	60º 49.625’	55º 38.665’	5	409	12	36.139	234
23	Elephant Island	60º 51.660’	55º 30.050’	3	261.9	14	80.747	147
24	Elephant Island	60º 52.975’	55º 27.825’	3	226	10	341.563	438
25	Elephant Island	60º 55.715’	55º 26.730’	2	105	9	47.496	69
26	Elephant Island	60º 52.695’	55º 21.170’	4	327	9	8.9371	132
27	Elephant Island	60º 58.125’	55º 04.815’	3	291	12	29.549	62
28	Elephant Island	61º 00.770’	55º 07.145’	2	132	8	86.098	133
30	Elephant Island	61º 03.135’	54º 44.035’	5	402	11	14.673	64
31	Elephant Island	61º 11.645’	54º 43.960’	3	240	10	24.196	72
32	Elephant Island	61º 16.015’	54º 53.935’	2	139	7	38.378	268
33	Elephant Island	61º 12.010’	54º 51.845’	1	70.4	6	12.158	122
34	Elephant Island	61º 10.095’	54º 33.535’	4	331	13	12.106	119
35	Elephant Island	61º 20.735’	55º 12.450’	3	244	12	56.535	113
36	Elephant Island	61º 20.405’	55º 30.170’	2	142	6	8.301	17
37	Elephant Island	61º 17.155’	56º 14.570’	4	302	8	16.627	33
38	Elephant Island	61º 25.940’	56º 07.715’	4	306	11	33.423	98
82	Elephant Island	61º 04.000’	54º 33.580’	2	198	6	35.966	46

Table 5.1. continued.

Table 5.2. Station and catch information for the 2001 AMLR finfish survey of the South Shetland Islands: lower South Shetland Islands stations.

Station	Region	Latitude	Longitude	Strata	Mean Depth	Number of Species	Total Catch (Kg)	Total Number
42	South Shetland Islands	61º 50.705	57º 20.025	3	252	9	56.83	177
43	South Shetland Islands	61º 39.395	57º 05.060	5	438	6	7.734	96
44	South Shetland Islands	61º 44.780	58º 02.180	3	242	10	147.165	168
45	South Shetland Islands	61º 39.100	57º 46.045	4	317	16	90.765	160
47	South Shetland Islands	61º 36.115	58º 33.830	4	332	11	66.55	221
48	South Shetland Islands	61º 49.525	58º 34.310	2	165	10	1567.753	1310
49	South Shetland Islands	61º 45.845	58º 33.875	3	261	11	483.837	456
50	South Shetland Islands	61º 48.355	58º 42.785	3	244	10	119.874	189
51	South Shetland Islands	61º 39.665	58º 49.415	4	357	13	76.73	1113
52	South Shetland Islands	62º 00.010	59º 12.600	2	126	11	69.178	126
53	South Shetland Islands	62º 00.715	59º 37.210	2	163	13	184.742	315
55	South Shetland Islands	61º 56.460	59º 35.535	3	235	13	63.193	140
56	South Shetland Islands	61º 58.975	59º 55.785	3	264	9	79.318	172
57	South Shetland Islands	62º 10.385	59º 25.875	1	62	2	4.345	6
58	South Shetland Islands	62º 06.745	59º 30.145	1	80.6	6	8.539	26
61	South Shetland Islands	62º 19.705	60º 29.460	2	113	12	50.326	167
62	South Shetland Islands	62º 06.105	60º 34.300	4	363	8	23.468	285
63	South Shetland Islands	62º 10.190	60º 49.015	5	403	8	35.544	1090
68	South Shetland Islands	61º 36.290	57º 14.910	5	426	10	10.36	63

69	South Shetland Islands	61º 38.175	57º 33.025	5	400	12	27.48	119
70	South Shetland Islands	62º 10.385	60º 28.365	2	174	14	63.967	244
71	South Shetland Islands	62º 26.340	61º 07.495	2	138	8	14.741	43
72	South Shetland Islands	62º 23.900	60º 56.855	1	92	7	35.714	80
74	South Shetland Islands	62º 23.910	60º 47.885	1	80	8	18.384	74
75	South Shetland Islands	62º 23.415	61º 24.580	4	344	14	47.66	763
77	South Shetland Islands	62º 41.895	61º 39.650	1	87	10	82.853	254
78	South Shetland Islands	62º 52.255	61º 48.600	2	141	13	60.182	187
79	South Shetland Islands	62º 49.870	60º 55.615	2	186	11	36.391	167
80	South Shetland Islands	62º 55.075	60º 54.545	2	175	7	6.088	39
83	South Shetland Islands	61º 51.395	59º 13.990	3	244	12	162.433	316
85	South Shetland Islands	61º 44.195	58º 20.525	3	272	13	147.879	188
86	South Shetland Islands	62º 40.025	61º 48.370	2	143	10	56.324	211
87	South Shetland Islands	62º 59.285	60º 57.800	4	359	16	30.88	452
88	South Shetland Islands	63º 04.705	60º 36.700	5	429	9	5.667	78

Table 5.2. continued.

Table 5.3. Total weight and numbers of species caught within the 500m isobath of Elephant Island.

	Depth											
	50-100m		100-200m		200-300m		300-400m		400-500m		Sum	
Species	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.
Bathylagus antarcticus									0.4	15	0.4	15
Bathyraja eatonii					4.5	2					4.5	2
Bathyraja maccaini	5.4	3	29.5	5	15.	2					49.9	10
*Bathyraja sp*2					0.3	2	1.1	2	0.3	3	1.6	7
Chaenocephalus aceratus	9.5	9	463.5	388	34.6	80	16.5	42	10.7	11	534.9	530
Champsocephalus gunnari	21.4	152	470.9	3219	55.1	82	3.9	8	1.7	2	552.9	3463
Chionodraco rastrospinosus			3.7	9	53.8	119	31.5	95	12.9	30	101.8	253
Cryodraco antarcticus					1.5	5	2.6	12	4.0	7	8.0	24
Dissostichus mawsoni	0.01	1	2.9	6	8.4	10	4.3	7	3.5	3	19.1	27
Electrona antarctica					0.04	3	0.5	36	0.4	47	0.9	86
Gobionotothen gibberifrons	3.6	5	1223.2	1670	396.2	445	41.1	69	8.0	11	1672.1	2200
Gymnoscopelus nicholsi					0.6	18	5.5	169	6.4	188	12.4	375
Gymnoscopelus opisthopterus									5.1	133	5.1	133
Icichthys australis									0.9	1	0.9	1
Lepidonotothen larseni			3.4	65	7.7	158	2.5	52	2.1	30	15.7	305
Lepidonotothen nudifrons	3.9	117	2.2	48	0.1	2					6.2	167
Lepidonotothen squamifrons					20.7	85	7.8	38	62.0	115	90.6	238
Magnisudis prionosa							0.1	1			0.07	1
Muraenolepis microps					0.3	2	0.6	1	1.2	5	2.1	8
Notothenia coriiceps	18.6	16	105.4	75	2.7	2	1.6	1			128.3	94
Notothenia rossii	1.8	2	16.4	17	11.7	9	2.7	2			32.6	30
Pachycara brachycephalum			0.04	1	0.4	6			0.05	1	0.4	8
Parachaenichthys charcoti	0.7	15	1.1	13	0.2	3					2.0	31
Paradiplospinus gracilis							1.0	1	0.09	1	1.1	2
Pogonophryne dolichobranchiata					0.2	1					0.2	1
Pogonophryne species							0.2	1	0.05	1	0.3	2

Table 5.3. continued.

Depth

	50-100m		100-200m		200-300m		300-400m		400-500m		Sum	
Species	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.
Pseudochaenichthys georgianus	2.0	1	32.9	24	4.4	7	3.3	6	0.5	1	43.2	39
Trematomus bernacchii	0.7	1	0.8	3							0.9	4
Trematomus eulepidotus					1.4	4	3.8	14	1.7	4	6.9	22
Trematomus hansoni			0.2	1							0.2	1
Trematomus newnesi	0.6	5	0.1	1							0.7	6
Trematomus spp.					0.01	2					0.01	2

Table 5.4. Total weight and numbers of species caught within the 500m isobath of the lower South Shetland Islands.

Depth

	50-100m		100-200m		200-300m		300-400m		400-500m		Sum	
Species	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.
Bathyraja eatonii					11.4	2			1.6	1	12.9	3
Bathyraja maccaini	3.4	11	0.2	2			0.8	1			4.4	14
Bathyraja sp2			1.1	1			3.7	35	1.2	5	5.9	41
Chaenocephalus aceratus	19.7	71	150.7	420	27.5	52	5.3	18			203.1	561
Chaenodraco wilsoni			0.4	4	0.5	1	0.1	1			0.6	6
Champsocephalus gunnari	44.0	159	148.2	555	29.9	50	13.6	91			235.6	855
Chionodraco rastrospinosus	0.6	1	10.9	21	281.4	581	90.5	242	17.4	35	400.9	880
Cryodraco antarcticus					1.9	2	32.1	42	6.4	9	40.4	53
Dissostichus mawsoni			5.2	21	12.8	14	3.2	4			21.2	39
Electrona antarctica					0.1	4	0.1	10	2.9	165	3.1	179
Gerlachea australis							0.1	1			0.6	1
Gobionotothen gibberifrons	1.1	3	101.9	210	330.5	582	19.1	39	3.7	7	456.3	841
Gymnodraco acuticeps					0.2	1	0.1	1	0.03	1	0.3	3
Gymnoscopelus braueri									0.5	9	0.5	9
Gymnoscopelus nicholsi	1.0	2	0.2	4	0.03	1	73.3	2143	38.2	1137	111.9	3287
Gymnoscopelus opisthopterus					0.04	1					0.04	1
Krefftichthys anderssoni			0.01	1							0.01	1

Table 5.4. continued.

Depth

	50-100m		100-200m		200-300m		300-400m		400-500m		Sum	
Species	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.
Lepidonotothen larseni	0.02	3	3.2	82	4.5	90	5.2	94	0.6	11	13.5	280
Lepidonotothen nudifrons	3.9	74	3.0	67	0.7	16	0.1	1			7.6	158
Lepidonotothen squamifrons							34.0	137	7.3	35	41.3	172
Muraenolepis microps									1.2	2	1.2	2
Notothenia coriiceps	60.0	61	1602.2	1285	485.3	295	20.5	17			2168.0	1658
Notothenia rossii	3.8	6	14.4	18	48.7	47	25.8	14	3.9	3	96.4	88
Ophthalmolycus amberensis					0.3	2	1.5	24	0.2	3	2.1	29
Pachycara brachycephalum			0.4	4	1.1	12	3.8	45			5.3	61
Pagetopsis macropterus			0.05	1							0.05	1
Parachaenichthys charcoti	2.4	36	1.2	18	1.4	21	0.3	6			5.3	81
Paradiplospinus gracilis							1.0	14	0.8	10	1.8	24
Pleuragramma antarcticum							0.2	5	0.9	12	1.1	17
Pogonophryne marmorata							0.1	1			0.1	1
Pseudochaenichthys georgianus	10.9	13	64.7	85	23.0	32					98.6	130
Trematomus bernacchii			0.3	1							0.3	1
Trematomus eulepidotus							0.7	3	0.1	1	0.7	4
Trematomus hansoni			1.0	4			0.7	4			1.7	8
Trematomus loennbergii			0.1	1							0.1	1
Trematomus newnesi			0.3	2							0.3	2
Trematomus pennellii			0.1	1							0.1	1
Trematomus scotti			0.1	1			0.1	1			0.2	2

Table 5.5. Estimated spawning time, gonado-somatic indices (GSI) at spawning, GSI in March 2001, and egg size at spawning for abundant nototheniids, bathydraconids and channichthyids in the Elephant Island-South Shetland Island region.

Species	Estimated spawning time	GSI at spawning	GSI in March 2001 *	Egg size (mm)
Notothenia rossii	May - June	20 - 30	10 - 12	4.7 - 5.0
N. coriiceps	May - June	23 - 28	8 - 12	4.4 - 4.7
Lepidonotothen squamifrons	February - April	unknown	unknown	Probably 1.4
L. larseni	July - August	unknown	8	1.8 - 2.0
L. nudifrons	April - May	23 - 28	18 - 22	2.5
Gobionotothen gibberifrons	July - August	unknown	8	1.7 - 2.0
Parachaenichthys charcoti	August	unknown	5	unknown
Champsocephalus gunnari	March - May (June)	23 - 28	5 - 18	3.5 - 3.7
Chaenocephalus aceratus	March - April	23 - 28	12 - 18	4.4 - 4.7
Pseuchaenichthys georgianus	June - July	10	23 - 28	4.5 - 4.8
Chionodraco rastrospinosus	March - April	18 - 24	23 - 28	4.5 - 5.0
Cryodraco antarcticus	March - April	10 - 18	unknown	4
Pachycara brachycephalum	Probably extended	unknown	unknown	6

* Figures may change slightly when all material is analysed.

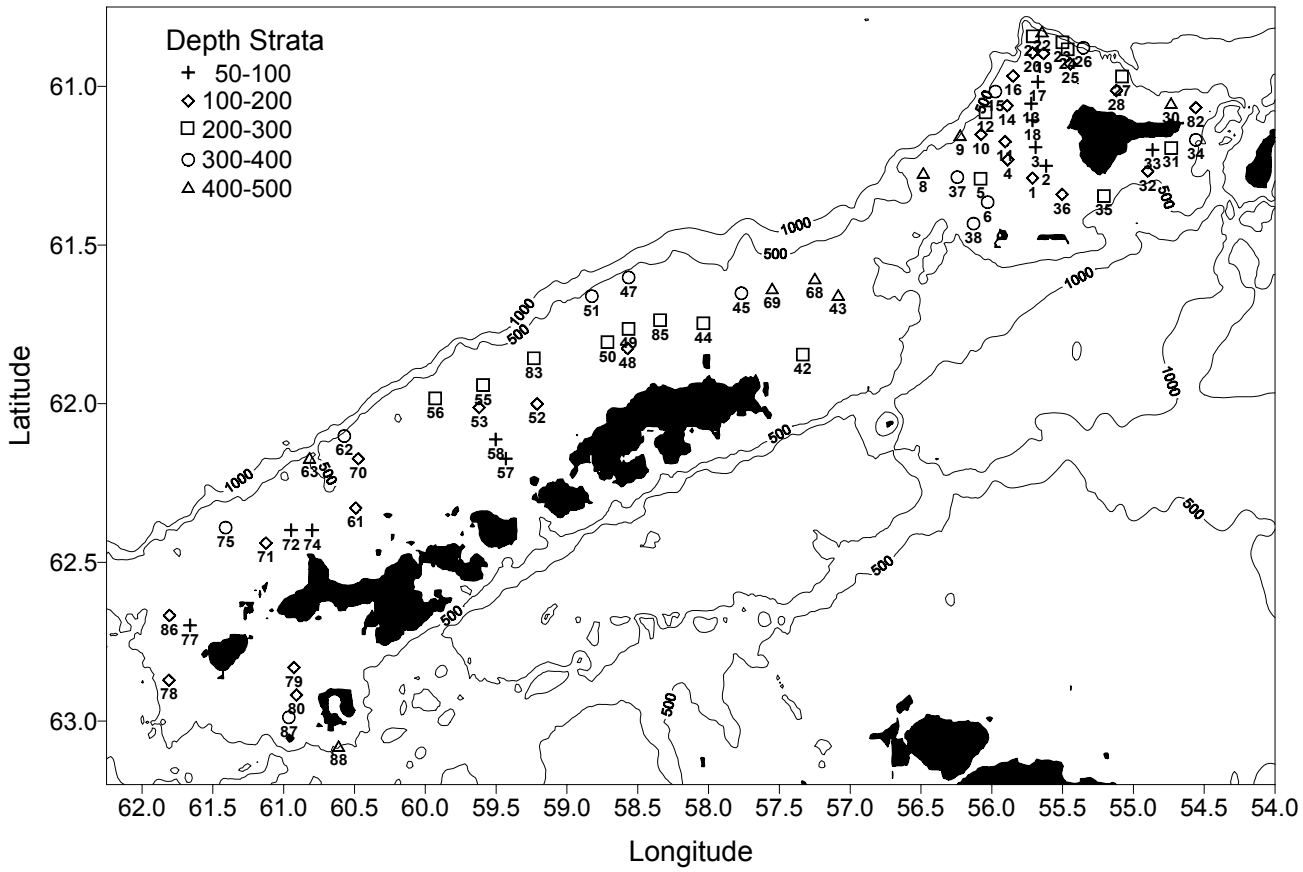

Figure 5.1. Station locations for the 2001 AMLR finfish bottom trawl survey. Longitude is West and latitude is South.

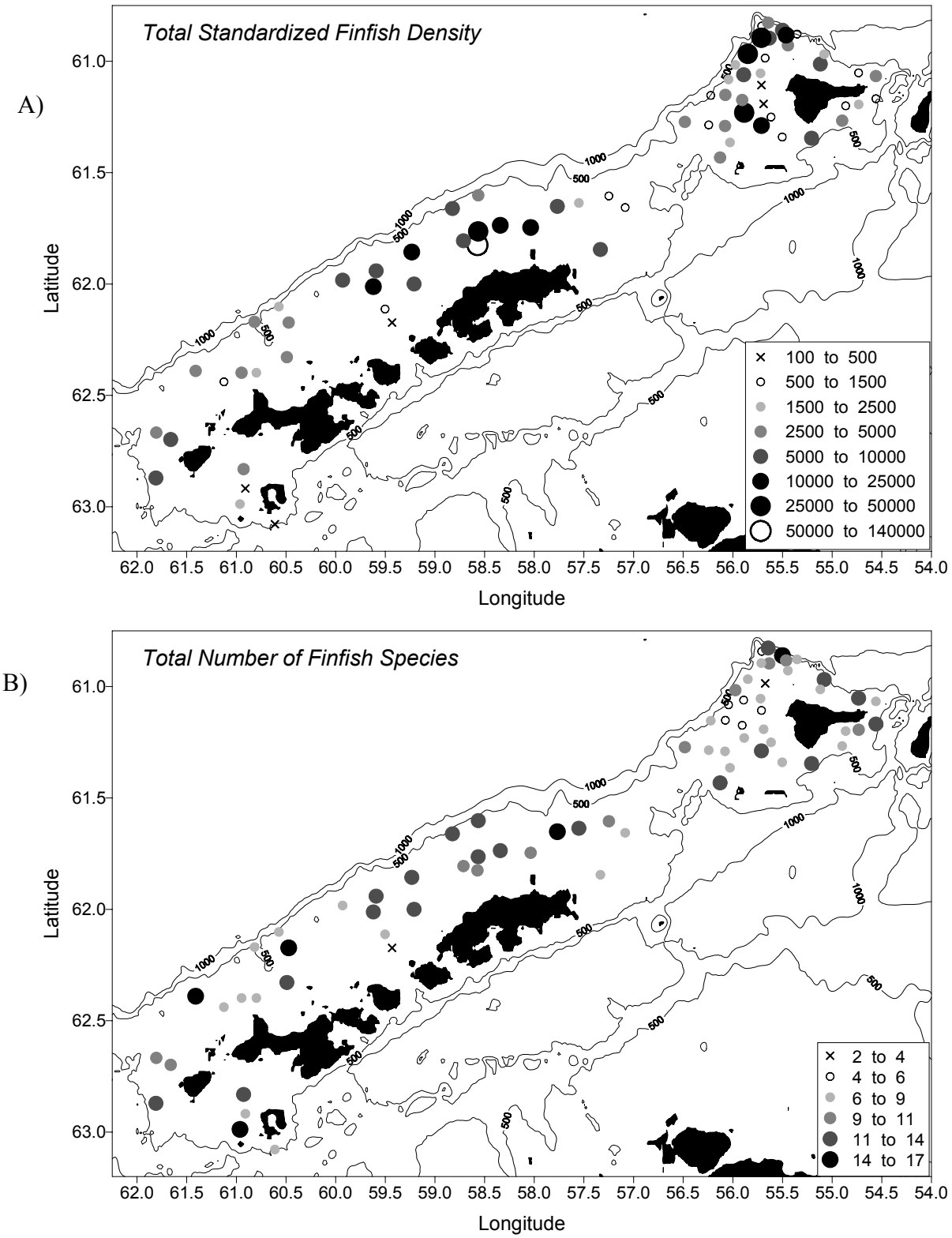

Figure 5.2. A) Total standardized finfish density in kg/nm^2, and B) total number of species taken from the 2001 AMLR finfish survey of the South Shetland Islands. Longitude is West and latitude is South.

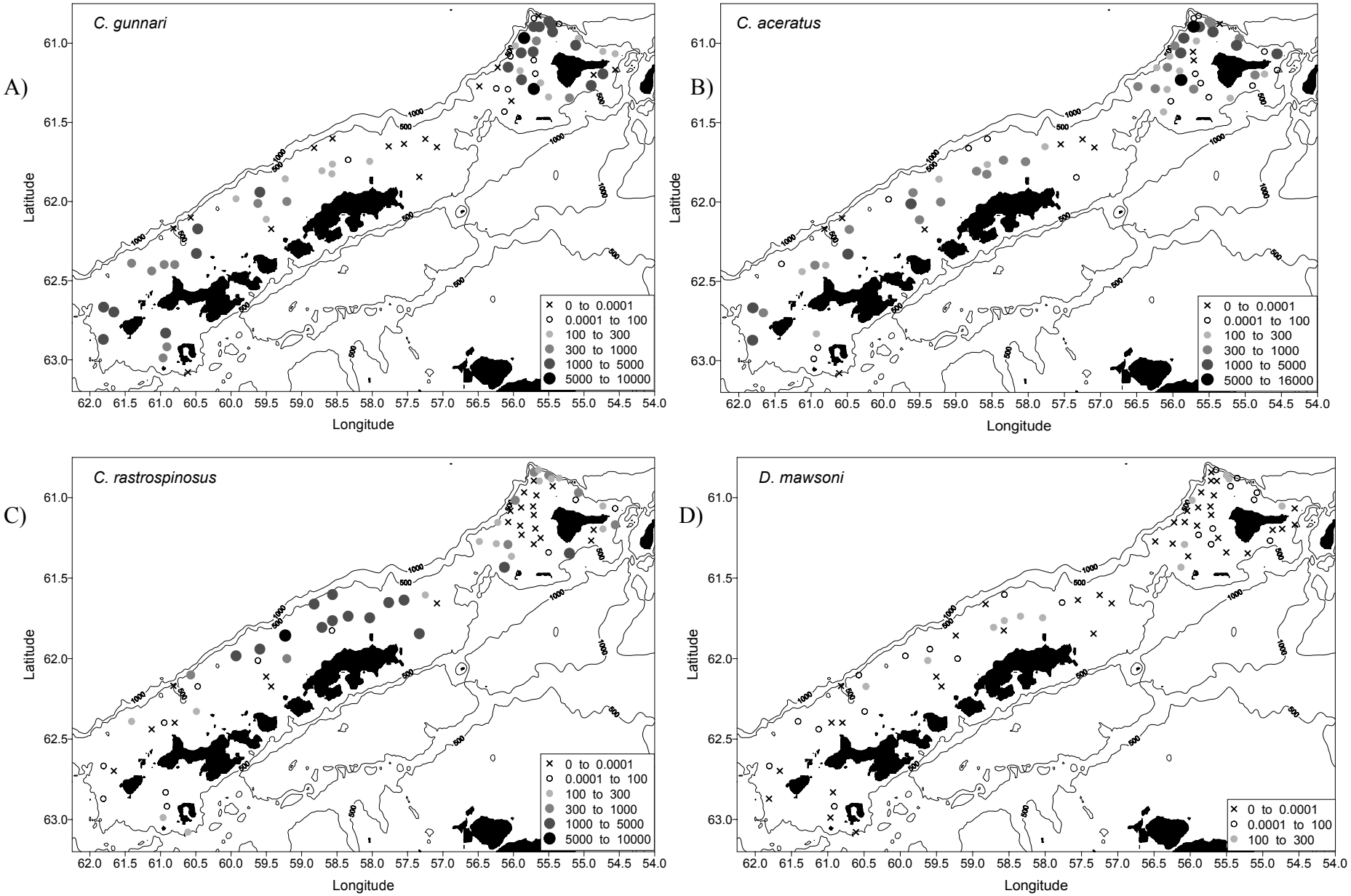

Figure 5.3. Standardized density (kg/nm^2) for A) *C. gunnari*; B) *C. aceratus*; C) *C. rastrospinosus*; D) *D. mawsoni* from the 2001 AMLR finfish survey of the South Shetland Islands. Longitude is West and latitude is South.

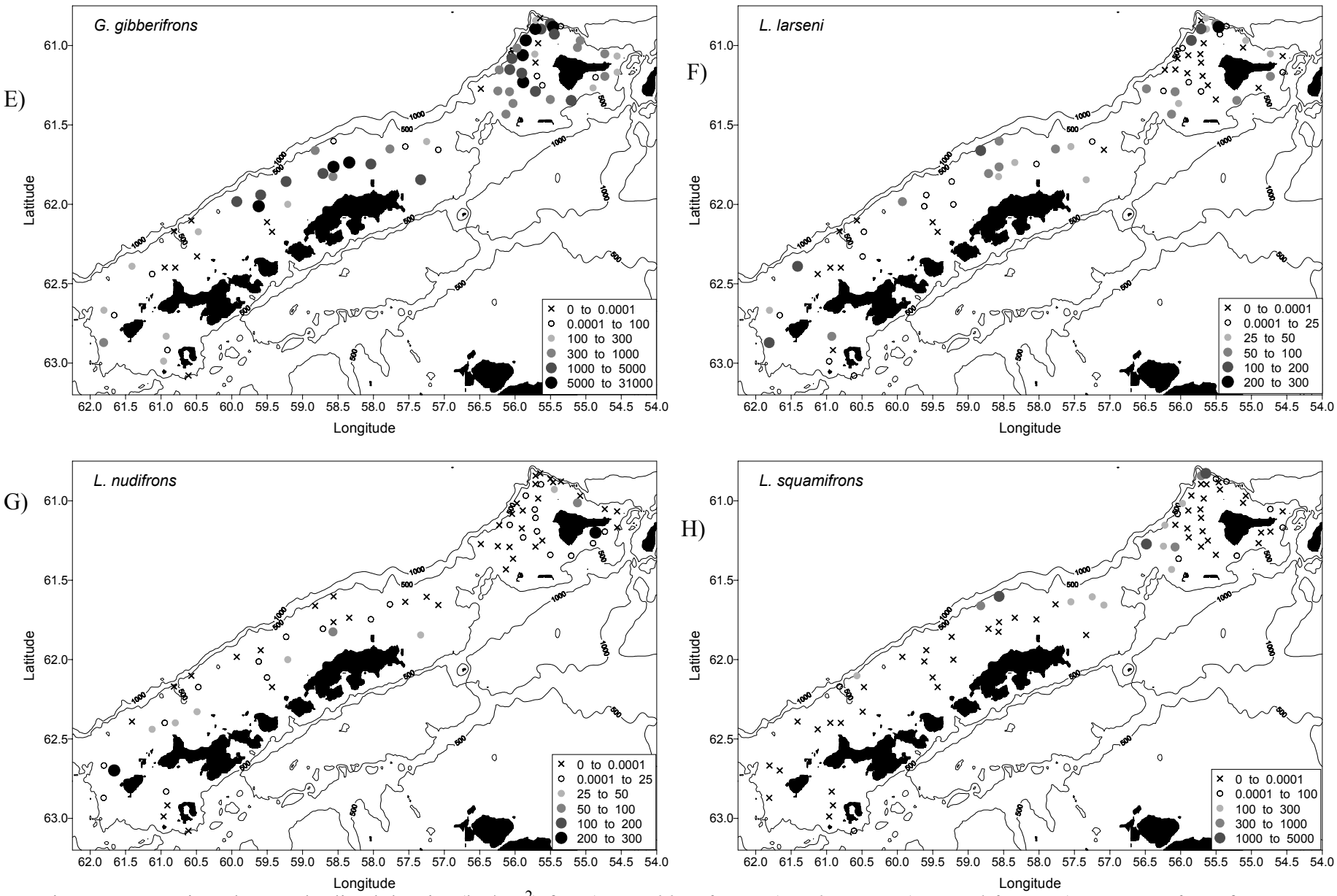

Figure 5.3. continued. Standardized density (kg/nm^2) for E) *G. gibberifrons*; F) *L. larseni*; G) *L. nudifrons*; H) *L. squamifrons* from the 2001 AMLR finfish survey of the South Shetland Islands. Longitude is West and latitude is South.

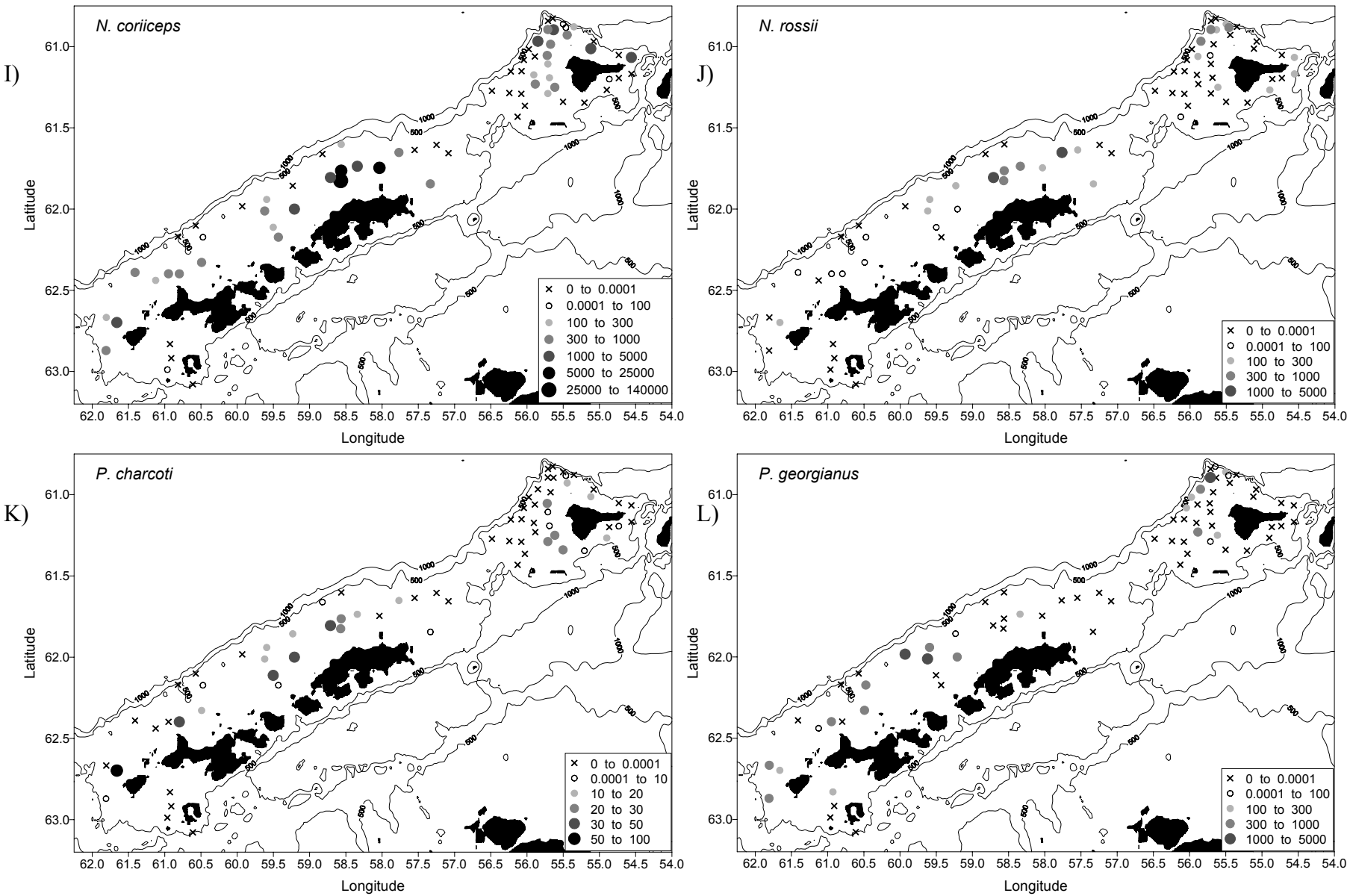

Figure 5.3. continued. Standardized density (kg/nm^2) for I) *N. coriiceps*; J) *N. rossii*; K) *P. charcoti*; L) *P. georgianus* from the 2001 AMLR finfish survey of the South Shetland Islands. Longitude is West and latitude is South.

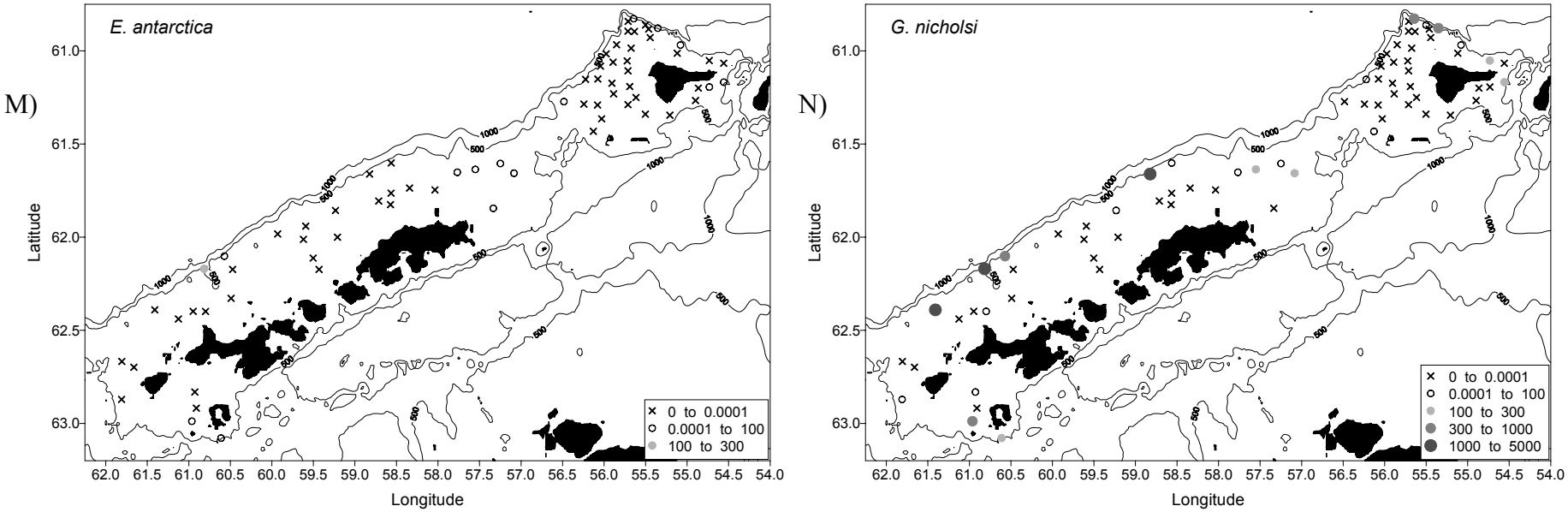

Figure 5.3. continued. Standardized density (kg/nm^2) for M) *E. antarctica*; N) *G. nicholsi* from the 2001 AMLR finfish survey of the South Shetland Islands. Longitude is West and latitude is South.

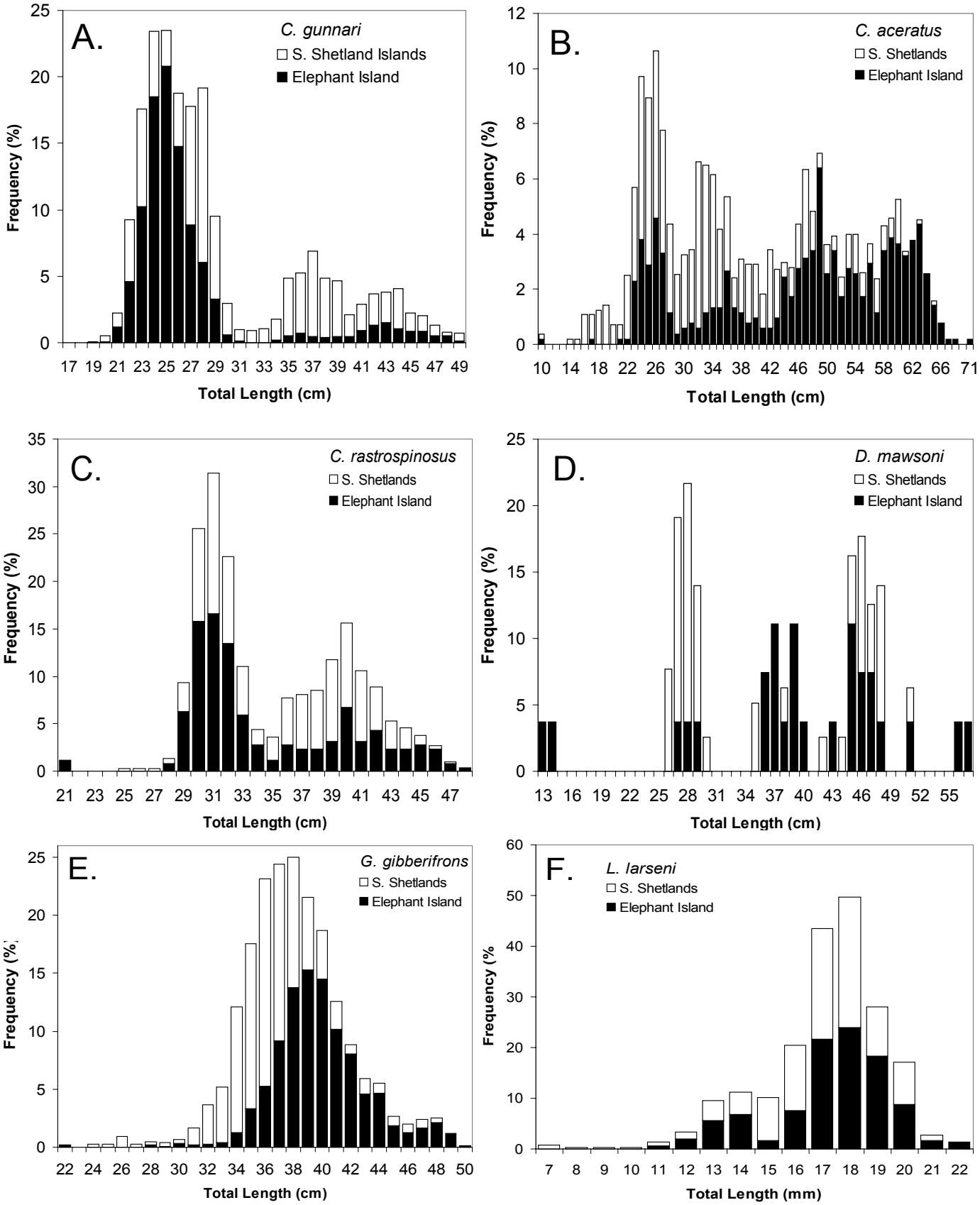

Figure 5.4. Length-frequency distributions for species with significant catches: A) *C. gunnari;* B) *C. aceratus*; C) *C. rastrospinosus*; D) *D. mawsoni*; E) *G. gibberifrons*; F) *L. larseni*;

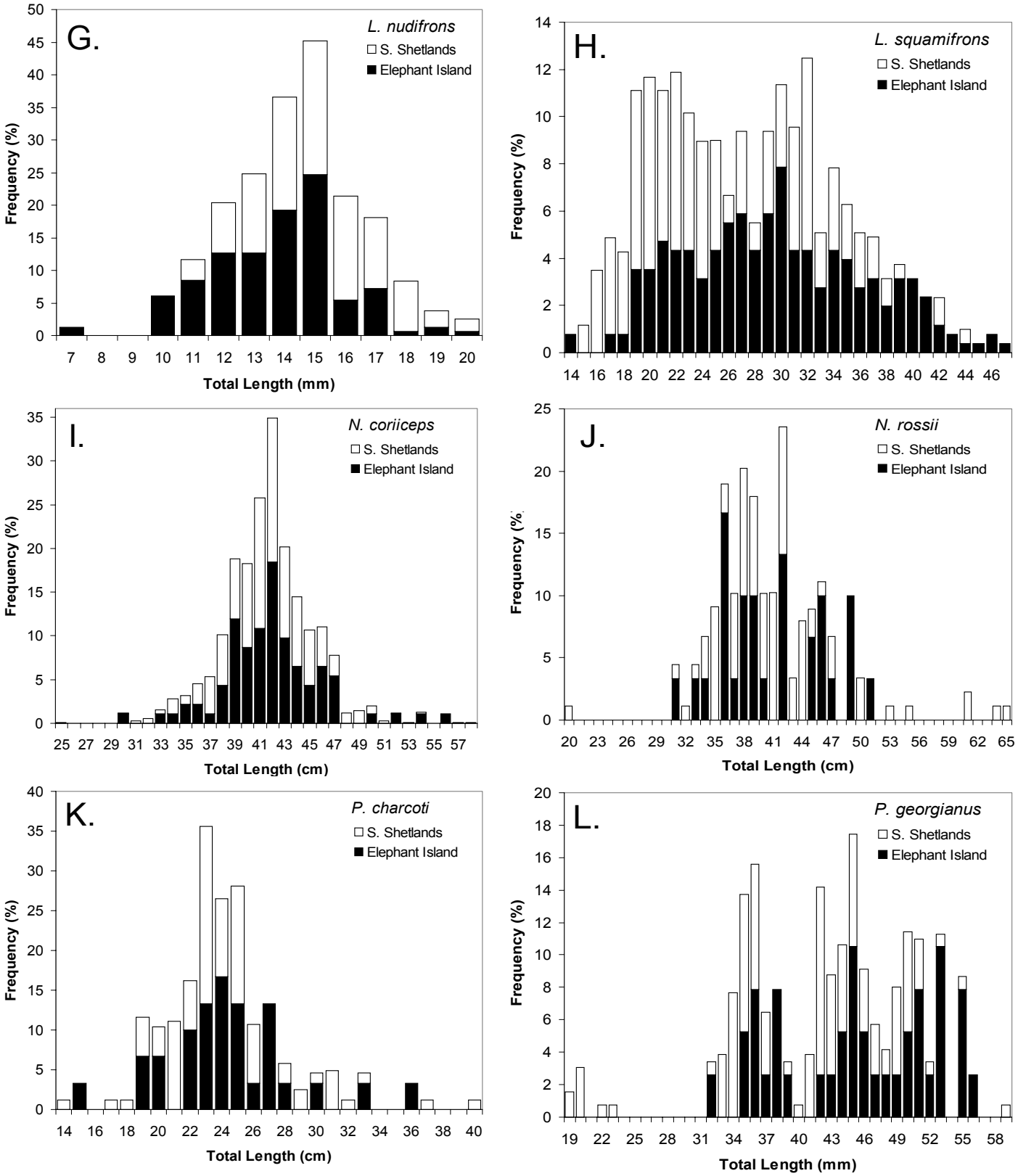

Figure 5.4. continued. Length-frequency distributions for species with significant catches: G) *L. nudifrons*; H) *L. squamifrons*; I) *N. coriiceps*; J) *N. rossii*; K) *P. charcoti*; L) *P. georgianus*.

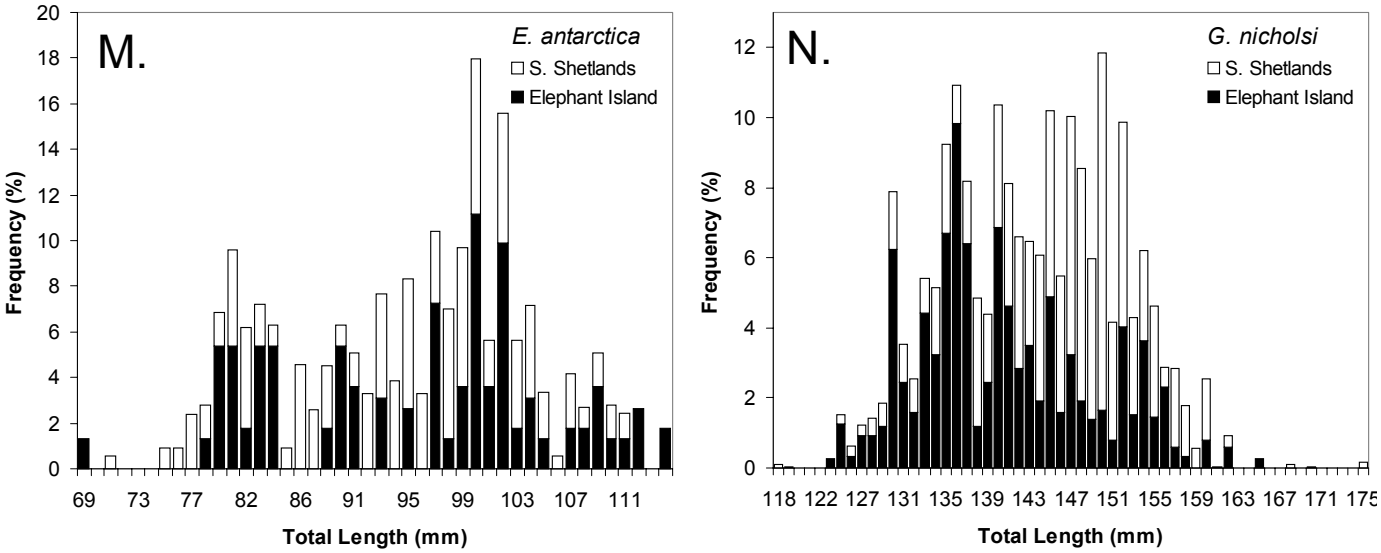

Figure 5.4. continued. Length-frequency distributions for species with significant catches: M) *E. Antarctica*; N) *G. nicholsi*.

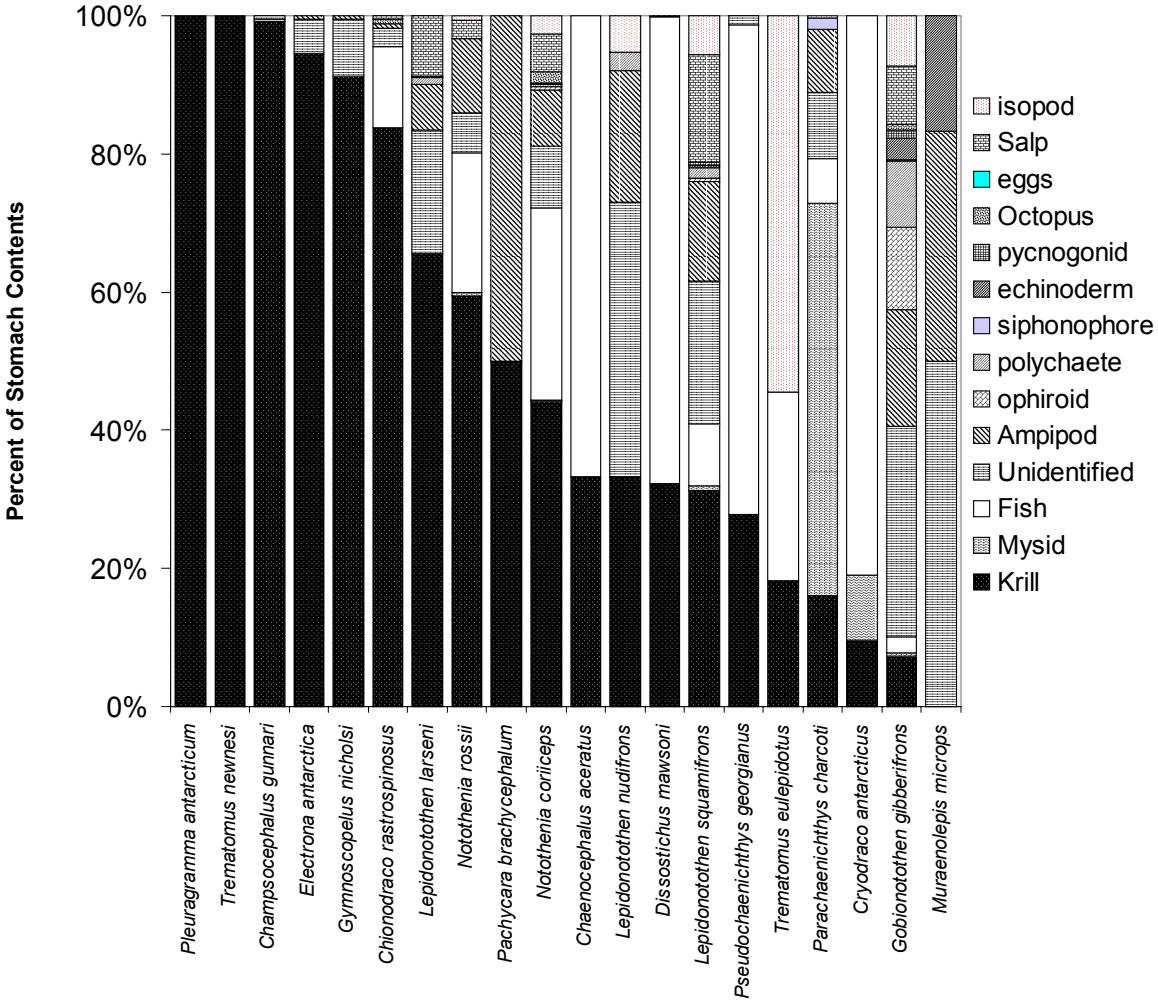

Figure 5.5. Summary of diet composition of 20 species of finfish, based on mean stomach content scores, from the 2001 AMLR finfish bottom trawl survey of the South Shetland Islands.

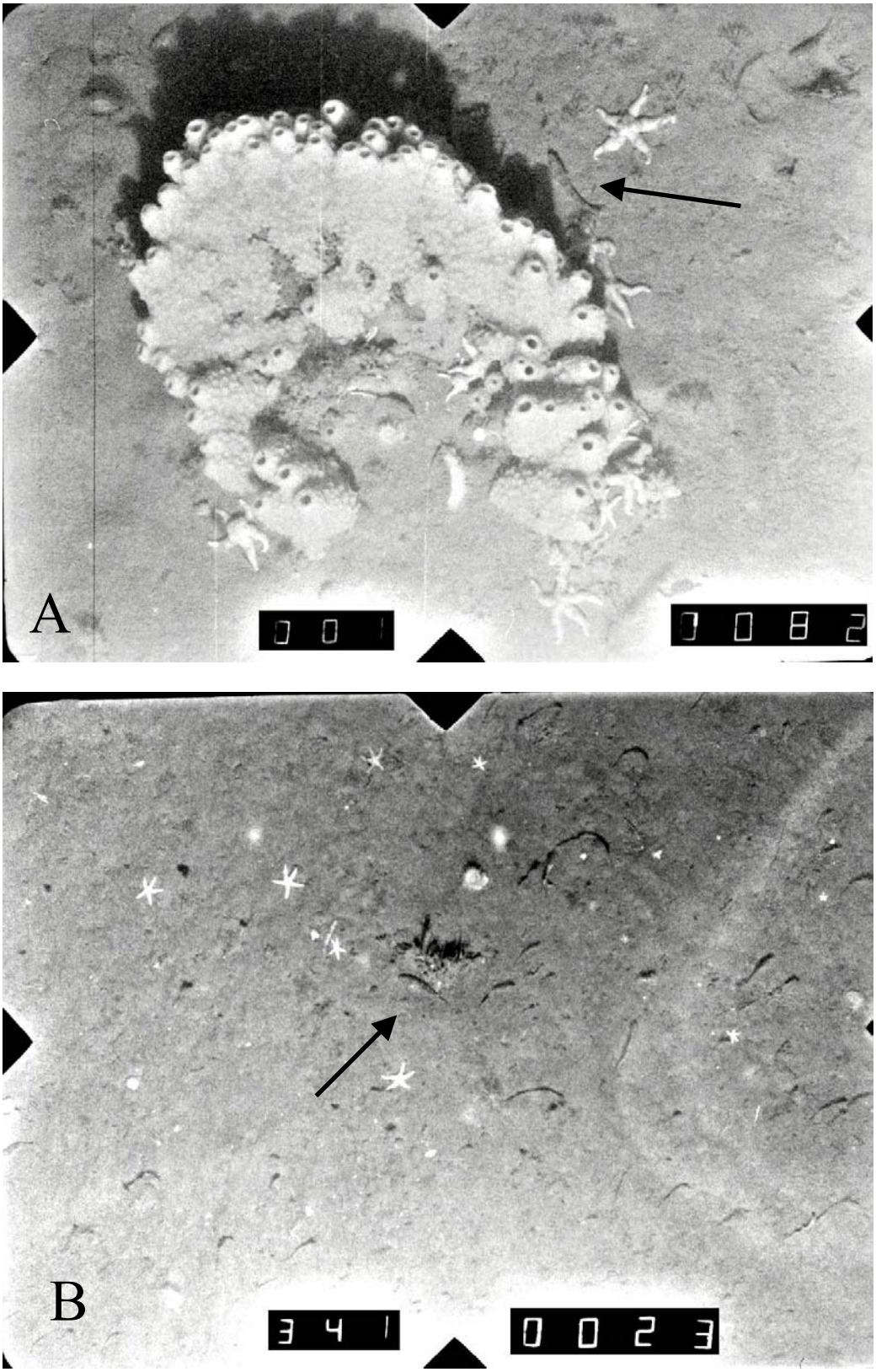

Figure 5.6. Video images of demersal finfish associated with benthic epifauna. Figure 5.6A was taken near Station 22 and 5.6B was taken near Station 26.

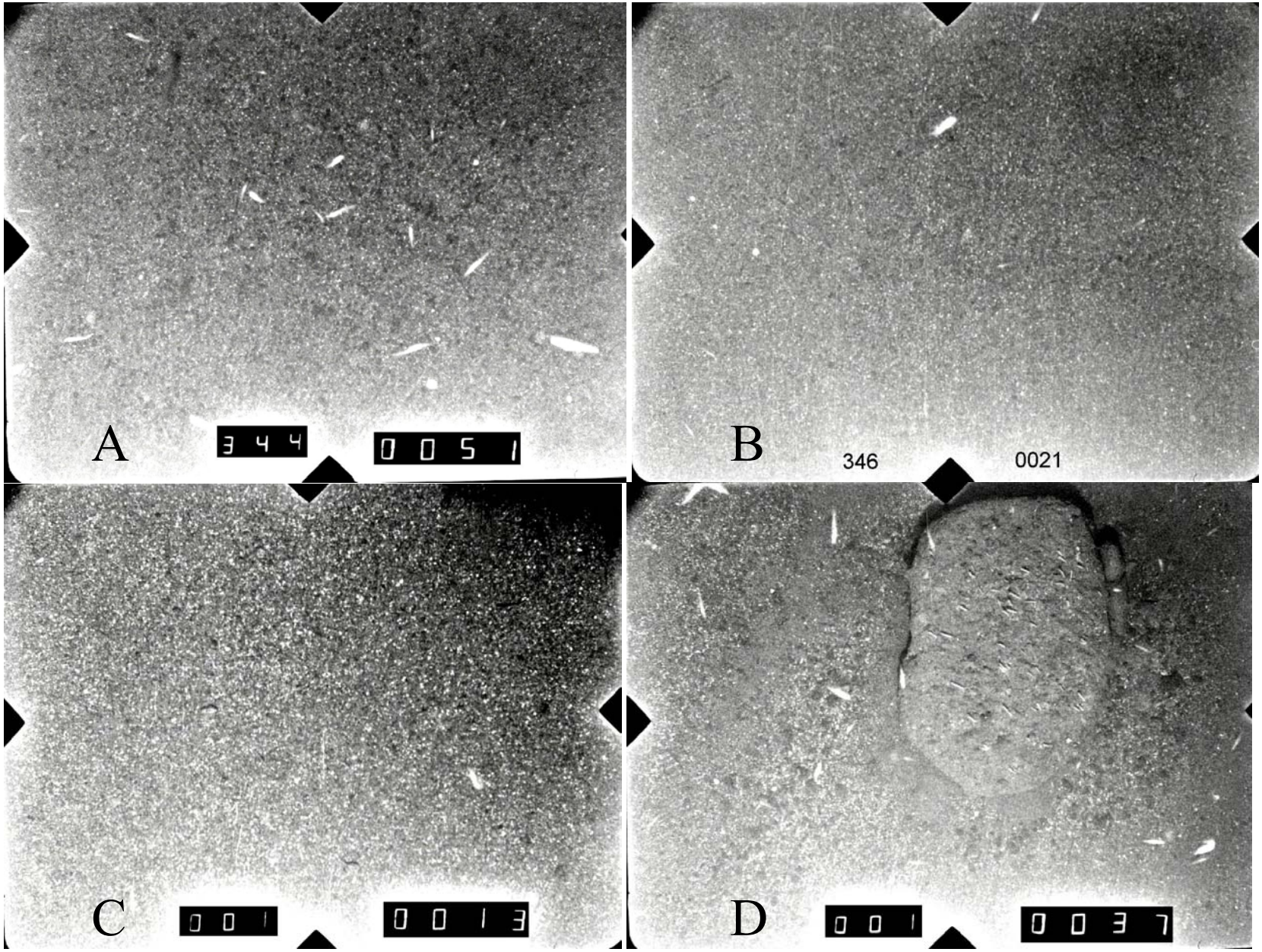

Figure 5.7. Video images of seabed features near Station 17 from the 2001 AMLR survey.

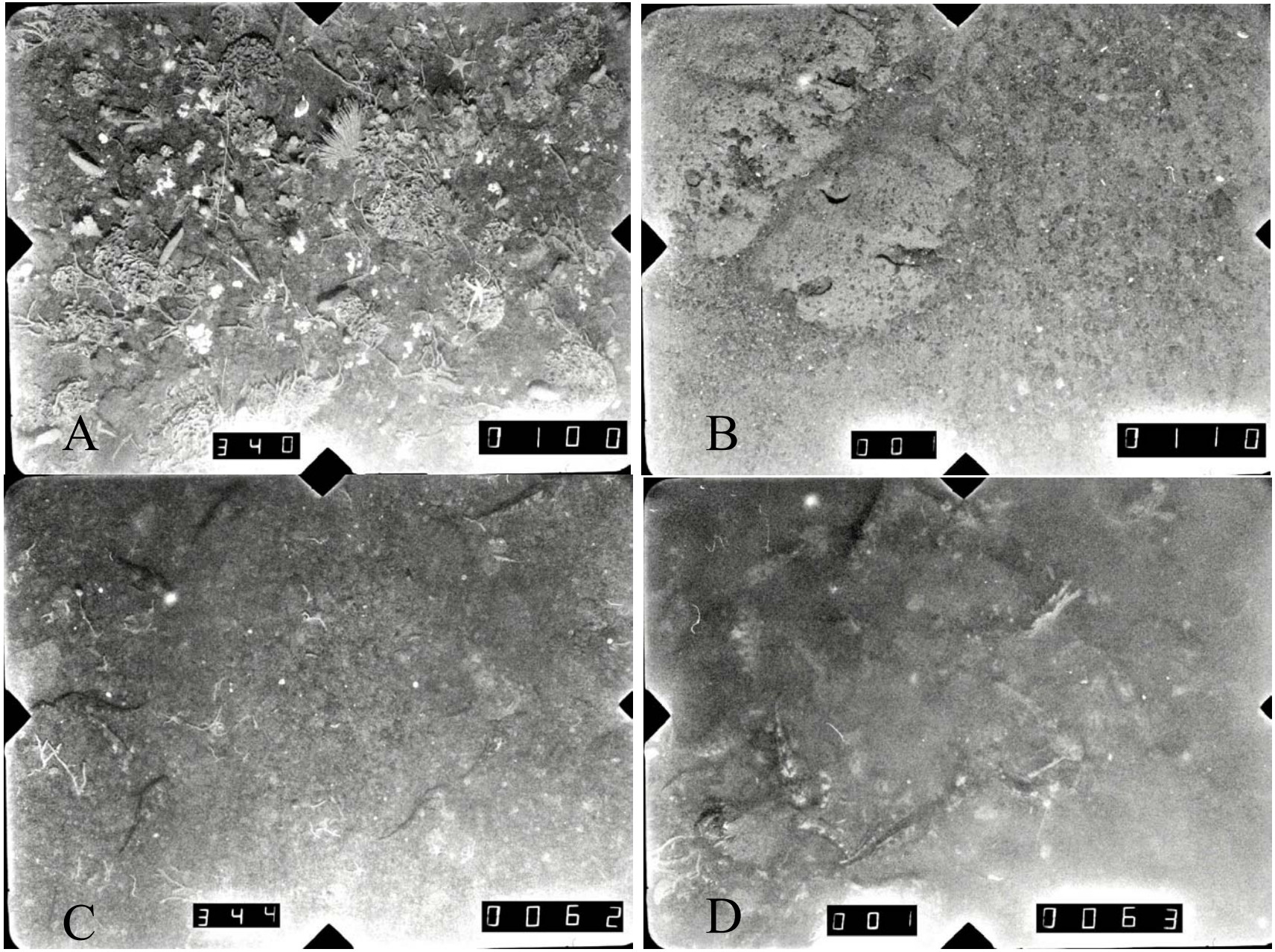

Figure 5.8. Video images of seabed features near Station 48 from the 2001 AMLR survey. *N. coriiceps* can be seen in 5.7C and 5.6D.