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Fisheries Investigations in Coastal Waters of Liverpool Bay, Northwest Territories

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by

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ABSTRACT

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In 1989 the Department of Fisheries and Oceans initiated a three-year study of the summer movement patterns of Arctic cisco (*Coregonus autumnalis*) in the eastern Beaufort Sea. During the first two years, work was carried out in Wood Bay, within the estuary of the Anderson River. This report presents results of the third summer's work, conducted on the west coast of Liverpool Bay. Shore-based trap nets fished between 11 July and 5 September 1991 yielded 39 005 fish; the dominant species being Arctic cisco, saffron cod (*Eleginus gracilis*) and Arctic flounder (*Pleuronectes glacialis*), which made up 36, 31, and 24%, respectively, of the total. The coregonids, *C. nasus* (broad whitefish), *C. clupeaformis* (lake whitefish), *C. sardinella* (least cisco), and *Stenodus leucichthys* (inconnu) were less abundant than at Wood Bay. Included in this report are daily catch data for each of the 19 species captured, and data on length-frequency distribution, age and growth, sex ratios, state of maturity, and food habits for the more important or abundant species. Data are also presented on water temperatures, salinity, and relative water levels encountered during the summer.

Key words: Beaufort Sea; Liverpool Bay; anadromous coregonids; life history; migrations; Arctic cisco; *Coregonus autumnalis*; marine fish.

RÉSUMÉ

Bond, W.A., and R.N. Erickson. 1993. Fisheries investigations in coastal waters of Liverpool Bay, Northwest Territories. Can. Manuscr. Rep. Fish. Aquat. Sci. 2204: vi + 51 p.

En 1989, le ministère des Pêches et des Océans a entrepris une étude de trois ans sur les migrations estivales du cisco arctique (*Coregonus autumnalis*) dans l'est de la mer de Beaufort. Les travaux des deux premières années se sont déroulés dans la baie Wood, à l'intérieur de l'estuaire de la rivière Anderson. Ce rapport présente les résultats obtenus lors du troisième été de recherches, sur la rive ouest de la baie Liverpool. Les parcs en filet posés le long du littoral ont été relevés entre le 11 juillet et le 5 septembre 1991; ils renfermaient 39 005 poissons dont 36 % de cisco arctique, 31 % de navaja jaune (*Eleginus gracilis*) et 24 % de plie arctique (*Pleuronectes glacialis*). Les corégones, *C. nasus* (corégone tschir), *C. clupeaformis* (grand corégone), *C. sardinella* (cisco sardinelle) et *Stenodus leucichthys* (inconnu) étaient moins abondants que dans la baie Wood. Le rapport présente les prises quotidiennes de chacune des 19 espèces représentées ainsi que des données sur la distribution de la fréquence des longueurs, sur l'âge et la croissance, sur la proportion des sexes, sur le degré de maturité et sur les habitudes alimentaires des espèces les plus importantes ou les plus abondantes. Des renseignements sont également fournis sur la température, la salinité et les niveaux relatifs de l'eau au cours de l'été.

Mots clés: mer de Beaufort; baie Liverpool; corégones anadromes; cycle de vie; migrations; cisco arctique; *Coregonus autumnalis*; poisson marin.

INTRODUCTION

The Arctic cisco (*Coregonus autumnalis*) is an anadromous coregonid that spawns in the Mackenzie River and forages along the Beaufort Sea coast during the summer months. To date, most information relevant to the life history of Arctic cisco has come from fisheries studies in the Mackenzie River or west along the Yukon/Alaska coast (Stein et al. 1973; Craig and Mann 1974; Kendel et al. 1975; Moulton et al. 1985; Cannon et al. 1987; Bond and Erickson 1987, 1989; and others). Arctic cisco are also known to migrate eastward from the Mackenzie River along the coast of the Tuktoyaktuk Peninsula (Jones and den Beste 1977; Bond 1982; Lawrence et al. 1984; LGL 1989). However, the extent and periodicity of these eastward migrations are not well understood. Arctic cisco also occur in Liverpool Bay (Bray 1975; Gillman and Kristofferson 1984), but the relationship of these fish to Mackenzie stocks has not been clarified. The general lack of information on the distribution and abundance of Arctic cisco to the east of the Mackenzie, and particularly on the significance of the Liverpool Bay area to Mackenzie River stocks, represents a major gap in our understanding of this important species.

The current study was initiated in 1989 to address the need for information on the status of Arctic cisco in habitats located east of the Mackenzie River. The objectives of the study are to: 1) determine whether major rearing/overwintering of juvenile Arctic cisco from the Mackenzie River occurs east of the Mackenzie Delta; 2) identify specific areas to the east of the Mackenzie Delta that may be critical to the maintenance of Mackenzie River stocks; and 3) quantify the significance of such eastern locations to Mackenzie River populations. Field work in 1989 and 1990 was conducted on the east coast of Wood Bay near the mouth of the Anderson River (Bond and Erickson 1991, 1992). The present report summarizes results obtained in 1991, the final year of the study, during which the sampling effort focused for the first time on migrations of Arctic cisco along the west coast of Liverpool Bay.

STUDY AREA

The 1991 Liverpool Bay study area was located at 69°50'N, 130°20'W on the south shore of the Tuktoyaktuk Peninsula, approximately 50 km west of the Anderson River (Fig. 1). This particular location was selected for logistical reasons and because it afforded protection from severe weather conditions. It differed from the previously studied Wood Bay site in that no major river enters nearby. Liverpool Bay is an elongate water body about 12 km wide at our location with a maximum depth exceeding 16 m. It connects with a large freshwater lake system (Husky Lakes) at its south end and with the open Beaufort Sea to the north. The bay receives Mackenzie-influenced surface water from the Beaufort Sea and additional fresh water from Husky Lakes (Grainger 1975). Several small rivers (Miner, Kugaluk, Moose, Smoke) also enter Liverpool Bay near its south end. Maximum water temperature and salinity recorded at our site in 1991 were 12.5°C and 13.1 $g \cdot kg^{-1}$. In the deeper parts of Liverpool Bay, salinity can remain above 30 $g \cdot kg^{-1}$ throughout July and August (Grainger and Lovrity 1975).

MATERIALS AND METHODS

FIELD METHODS

Physical and chemical

Environmental parameters measured during this study included water temperature, salinity, and water level. Surface water temperature and salinity were determined at the trap netting sites during each trap check, at each gill net set, and at a site within the inner bay from 1 July to 1 September. Water temperature (±0.5°C) was measured using a hand-held pocket thermometer. Water samples for salinity analysis were taken in 1 L Nalgene bottles or with a 2 L Van Dorn water sampler and transported directly to the field laboratory where salinity (±0.1 $g \cdot kg^{-1}$) was determined using a YSI Model 33 salinity meter. Relative water levels were obtained from a staff gauge located inside the inner bay. As many as 13 readings were taken each day in an effort to identify daily high and low water levels.

Trap net sampling

The sampling gear consisted of a double codend trap with a single lead extending perpendicularly to the shoreline and two 15.2 m wings set at 45° angles to the lead. Similar gear, differing only in lead length, has been utilized in numerous recent studies on the Beaufort Sea coast (Moulton et al. 1985; Cannon et al. 1987; Bond and Erickson 1989, 1991, 1992; LGL 1989; Palmer and Dugan 1990). The funnel mouth leading to each codend trap was supported by a stainless steel frame 1.7 m high by 1.8 m wide. Traps were 3.7 m long and 0.9 m on a side, contained five internal stainless steel frames and two throats (15 x 25 cm), and were constructed of 1.27 cm dark grey #147 knotless nylon mesh. Wings and leads were made of 2.54 cm dark grey #63 knotless nylon. Traps, leads, and wings were equipped with zippers, installed in such a way that they could be attached in any combination. Wings and leads were both 1.7 m deep and built in 15.2 m sections.

Two stations (601 and 602) were established on the west side of Liverpool Bay in 1991 (Fig. 2). Because of the very gradual slope of the seabed from the shoreline, it was necessary to employ longer leads than were used at Wood Bay in 1989 and 1990 (Bond and Erickson 1991, 1992). Station 601, which incorporated a 75 m lead, was installed initially on 11 July, but ice forced its removal on 13 July and delayed permanent installation until 22 July. Station 602, with a 60 m lead was installed on 25 July. Once permanent installation was achieved, fishing continued until 1 September at both locations. Traps were checked daily. On each occasion trapped fish were removed from the codend to a floating holding pen for processing and the trap was reset immediately. Total fishing effort was approximately 43 net-days at Station 601 and 38 net-days at Station 602 (Table 1).

All trapped fish were identified to species and counted. Routine measurement of non-coregonid species was limited to saffron cod, Pacific herring, and rainbow smelt, each of which was measured (fork length (FL) ±1.0 mm) to a maximum of 10 fish per codend per day. Because of the small catches, it was possible to measure virtually all least cisco, broad whitefish, lake whitefish, and inconnu taken. For Arctic cisco, separate counts were maintained for large (≥150 mm) and small (<150 mm) individuals and fork lengths were taken for a maximum of 50 large and 50 small fish per codend per day. Ratios from these subsamples were applied to total counts of large and small fish and the results combined to produce length-frequency descriptions of the total catch. Small numbers of each coregonid species were sacrificed for biological analysis (see below).

Gill net sampling

Variable mesh gill nets were used to monitor for the presence of Arctic cisco prior to trap installation (1-18 July) and to check for the presence of fish in offshore waters of Liverpool Bay. Gill nets were 60 m long by 1.8 m deep and consisted of equal length panels of 3.8, 5.1, 6.4, 7.6, 8.9, and 10.2 cm braided nylon mesh (stretch measure) seamed together. A total of 14 sets were made at six shoreline locations, and seven sets were made in 5 m of water at a single "offshore" site (Fig. 2) between 1 July and 28 August, with soak times ranging from 75 to 1420 minutes (Table A1). All gill netted fish were retained for biological analysis (see below).

LABORATORY METHODS AND DATA ANALYSIS

Nine of the fish species captured in the trap nets were considered sufficiently important or abundant to warrant some level of analysis. These included Arctic cisco, least cisco, broad whitefish, lake whitefish, saffron cod, rainbow smelt, Pacific herring, fourhorn sculpin, and Arctic flounder.

Catch-per-unit-effort

The catch-per-unit-effort (CPUE) for each species was calculated as the number of fish captured per day (24 h) in each codend trap. Separate CPUE determinations were made for large and small Arctic cisco and large and small least cisco. The division between large and small least cisco was made at 180 mm. Station CPUE's, the sums of the CPUE values for the individual codends, were pooled by weekly cycles for graphing to eliminate short-term fluctuations and emphasize seasonal trends. Inclusive dates for the sampling cycles referred to in the text are presented in Table 1.

Length-frequency distribution

The length-frequency distribution for each key species was determined by weekly sampling period for each codend trap at each station. For purposes of this report, length-frequencies for least cisco, broad whitefish, lake whitefish, saffron cod, Pacific herring, and rainbow smelt are presented for the total sample and for each sampling station. Length-frequency distributions for Arctic cisco are presented as well by weekly intervals in order to demonstrate temporal changes.

Biological analysis

Samples of each coregonid species taken in the trap nets were retained for more complete biological evaluation. These samples were not selected randomly from the catch, but rather were chosen to ensure representation across the full size ranges of fish occurring in the trap net catches. For these fish, as well as for all coregonids captured in gill nets, fork length (± 1.0 mm) was recorded and body weight (± 1.0 g) was determined using an electronic balance. Sex was determined by gross examination of the gonads and a qualitative description of the degree of gonadal development was applied according to the following scale:

Female	Male	
1	6	Immature
2	7	Maturing
3	8	Mature
4	9	Ripe
5	10	Spent
0		Sex Indistinguishable

To provide a more quantitative assessment of the degree of sexual development, gonads were removed from the fish and weighed fresh (± 1.0 g). The data on body and gonad weight were then used to calculate the gonadosomatic index (GSI) by the formula:

$$GSI = (\text{gonad weight} \times 100) \cdot \text{fish round weight}^{-1}.$$

Scales and sagittal otoliths were collected for age determination. Scales were employed primarily to age young specimens (<6 years) and to assist in the interpretation of otoliths. Otolith ages were determined by the break and burn method (Barber and McFarlane 1987).

The stomachs of sacrificed coregonids were examined in the field for evidence of feeding activity. A limited number of stomachs, selected because they contained food, were preserved in 10% formalin for further analysis. In the laboratory the contents of these stomachs were removed and the food items separated into major taxa. Unidentifiable material or debris were combined into a category termed "residue". After separation into categories, the organisms were placed on absorbent paper to remove excess moisture and the wet weight (± 0.01 g) was determined using a Mettler PL 1200 balance. For age 0 Arctic cisco, food items in each stomach were simply counted.

Weight-length relationships for Arctic cisco and least cisco were described by the power equation:

$$\log_{10} W = a + b(\log_{10} L)$$

where W = weight (g)
L = fork length (mm)
a = y-intercept
b = slope of the regression line

Weight-length relationships were also determined for saffron cod and Pacific herring based on fish captured in gill nets.

Relative condition factors (K) were determined from the formula:

$$K = (W \times 10^5) \cdot L^{-3}$$

where W = weight (g)
L = fork length (mm).

RESULTS

PHYSICAL AND CHEMICAL

Without the benefit of a nearby river to assist in the breakup process, ice often persists in Liverpool Bay until mid-July. By 22 June 1991, ice had just begun to leave the shoreline of the small bay on which our camp was located and solid ice occupied Liverpool Bay north of our site. Over the next several weeks, this ice gradually broke up and the extent of open water increased. During this period, north and west winds tended to blow ice pans away from the study area; however, a change in wind direction to south or east often caused ice to move back into the bay, delaying final installation of the trap nets until 22 July.

Water levels fluctuated greatly at Liverpool Bay in 1991 (Fig. 3). Observed water levels varied over a range of 192 cm, the highest occurring on 9 August and the lowest on 12 August. Intraday variations ranged from 42 to 145 cm with a mean value of 80 cm (SD = 23.5).

Water temperatures tended to be warmer inside the inner bay (camp) than at the trap net locations (Fig. 4), whereas salinity values were usually similar at all three sites (Fig. 5). Water temperatures ranged from 5.0 to 15.5°C in the inner bay, from 4.0 to 11.5°C at Station 601, and from 5.0 to 12.5°C at Station 602. Water temperatures rose gradually to a peak at the end of Cycle 3, but were set back by a severe northwest storm on 3-4 August. Salinity ranged from 5.7 to 11.8 $g \cdot kg^{-1}$ in the inner bay, from 5.1 to 13.1 $g \cdot kg^{-1}$ at Station 601, and from 5.1 to 11.4 $g \cdot kg^{-1}$ at Station 602. The trend was one of gradually decreasing salinity until early August followed by rising values until the end of the study period.

TRAP NET RESULTS

Complete daily summaries showing the total trap net catch by sampling station and side of net are presented in Tables A2.1 to A2.11 for each of the key species. Separate break-downs are provided for large and small Arctic and least cisco. Daily catches by station for the remaining 10 species are given in Tables A3.1 and A3.2. Tables A4.1 and A4.2 contain length-frequency data for Arctic cisco by sampling cycle and side of trap for each station. Length-frequency data for saffron cod, Pacific herring, and rainbow smelt are shown by sampling cycle and station in Tables A5.1 to A5.6. Table A6 provides length-frequency data for all fish captured in gill nets.

Species composition

Trap netting at Liverpool Bay in 1991 produced 19 fish species representing nine families (Table 2). The composition of the catch (Table 3) differed markedly from that observed at Wood Bay in 1989 and 1990 (Bond and Erickson 1991, 1992). This is thought to be due to the distance of the 1991 study area from any major river and its proximity to the deeper offshore waters of Liverpool Bay. Seven freshwater species taken in Wood Bay (Arctic lamprey, Arctic grayling, round whitefish, northern pike, longnose sucker, burbot, and lake chub) did not occur in the Liverpool Bay catch. On the other hand, the Liverpool Bay results included four marine species not seen at Wood Bay (Greenland cod, Arctic sculpin, Arctic staghorn sculpin, and Pacific sand lance). Compared to Wood Bay, the Liverpool Bay results showed greatly reduced catches of least cisco, broad whitefish, lake whitefish, and inconnu, species that tend to remain close to their home rivers.

The 1991 trap net catch was dominated by three species; Arctic cisco (35.8%), saffron cod (30.8%), and Arctic flounder (24.3%) (Table 3). Rainbow smelt (2.5%), Pacific herring (2.4%), least cisco (1.7%), and fourhorn sculpin (1.0%) accounted for most of the remainder. The five coregonid species contributed from 4.1 to 93.6% of the weekly catch at Station 601 and from 13.1 to 83.6% at Station 602 (Table 4). These numbers effectively mirror the abundance of Arctic cisco which comprised 93.1% of all coregonids, followed by least cisco (4.4%), broad whitefish (1.9%), lake whitefish (0.6%), and inconnu (<0.1%).

Some inter-station differences in species composition and CPUE were observed in 1991 (Tables 5 and 6). For example, CPUE tended to be higher at Station 601 for large Arctic cisco, saffron cod, and Arctic flounder while small Arctic cisco, rainbow smelt, and broad whitefish were more abundant at Station 602. These differences do not appear to be related to water temperature or salinity which were similar at the two sampling sites.

During 1989 and 1990, we identified numerous coregonids in Wood Bay as possible hybrid forms. Subsequent morphological, meristic, and genetic analyses confirmed the occurrence in Wood Bay of crosses involving all five coregonid species (Reist et al. 1992). No such hybrid fish were identified from the Liverpool Bay catch in 1991.

Arctic cisco

Size distribution and seasonal abundance: Arctic cisco taken in the trap nets at Liverpool Bay during 1991 ranged in fork length from 43 to 460 mm based on measurements of 7790 individuals. The length-frequency distribution (Fig. 6) differed from that observed at Wood Bay during the previous two summers (Bond and Erickson 1991, 1992). Compared to the Wood Bay situation, Liverpool Bay samples included a much greater abundance of age 0 fish (50-69 mm), a conspicuous gap in the length-frequency distribution at the 100-139 mm size range suggesting a dearth of age 1 individuals, and stronger representation from intermediate-sized fish (150-279 mm) which accounted for 39% of the total Arctic cisco catch. Seasonal changes occurring in the length-frequency distribution of Arctic cisco during 1991 are demonstrated in Fig. 7.

Large Arctic cisco (≥150 mm) dominated early trap net catches, accounting for 99% of Arctic cisco taken during the first two weeks of sampling (Fig. 7). Gill netting prior to the final installation of the traps indicated that large cisco were already present in the study area by early July. Cisco taken in this gear between 1 and 18 July (n = 222) ranged from 180 to 449 mm in fork length. The modal size interval for fish in this sample was 370-379 mm and 65% of the catch was between 350 and 399 mm. This early presence probably represented the beginning of the major movement of large Arctic cisco into and through the study area that was detected in late July. As shown in Fig. 8, this run peaked during Cycle 2 (19-25 July) when CPUE averaged 439 fish•d^{-1} at Station 601. Catch rates fell abruptly after this early peak and remained in the range of 22-56 fish•d^{-1} for most of August. A smaller abundance peak during the last week of August saw catch rates rise to 197 fish•d^{-1} at Station 601 and 89 fish•d^{-1} at Station 602.

Overall catch rates for large Arctic cisco were 125 fish•d^{-1} at Station 601 and 79 fish•d^{-1} at Station 602 (Table 6). These greatly exceeded the overall CPUE values for large Arctic cisco recorded at Wood Bay in 1989 (8-37 fish•d^{-1}) and 1990 (33-48 fish•d^{-1}). A major reason for this difference was the large representation in the Liverpool Bay samples of intermediate-sized fish in the 150-279 mm range compared with their weak presence at Wood Bay. During 1991, fish in the 150-279 mm size-range accounted for 39% of the total Arctic cisco catch and 65% of all "large" cisco (i.e., ≥150 mm). The corresponding values recorded at Wood Bay were 3 and 12% (1989) and 13 and 19% (1990). The importance of these intermediate-sized fish to the 1991 catch is demonstrated in Fig. 9 which breaks the seasonal CPUE pattern for large Arctic cisco into two components, i.e., fish 150-279 mm (Fig. 9a) and fish ≥280 mm (Fig. 9b).

Small fish (<150 mm) accounted for 40% of the total Arctic cisco catch in 1991 with higher overall catch rates being recorded at Station 602 (120 fish•d^{-1}) than at Station 601 (25 fish•d^{-1}) (Table 6). Unlike at Wood Bay where small cisco were abundant only in early summer, fish of this size were not present in Liverpool Bay until late July 1991. The small fish arriving in late July were primarily age 0 (50-69 mm) (Fig. 7) whose appearance produced a major abundance peak in Cycle 3 (26 July - 1 August), particularly at Station 602 (Fig. 10). Following a major storm on 3-4 August, CPUE was sharply reduced although age 0 cisco continued to be captured in small numbers through the duration of the study.

Age and growth: Otolith age estimates for Arctic cisco captured in Liverpool Bay during 1991 ranged from 0 to 20 years (Table 7). Although the high initial catches of late July - early August were not sustained, total catch of age 0 cisco still exceeded the numbers taken at Wood Bay during the previous two summers. The gap in the length-frequency distribution between 100 and 139 mm (Fig. 6) indicates poor representation of individuals of both the 1990 (age 1) and 1989 (age 2) year-classes. Most cisco in the intermediate size ranges 150-279 mm appear to be age 3 and 4, i.e., members of the 1988 and 1987 years classes. Most large fish (330-399 mm) ranged in age from 8 to 13.

The mathematical relationship between fork length and body weight for Arctic cisco taken in Liverpool Bay during 1991 (Table 8) is described by the equation:

$$\log_{10}W = 3.2657 (\log_{10}L) - 5.6879$$

Sex and maturity: Sex was determined for 594 Arctic cisco at Liverpool Bay (includes fish captured in trap nets and gill nets) with males (n = 298) and females (n = 296) occurring in equal numbers. Among fish of potential spawning size (≥330 mm), females out-numbered males slightly (52%), but the male:female sex ratio of 0.92 did not differ significantly from unity ($X^2 = 0.57$; $P > 0.05$). The Liverpool Bay situation differed, therefore, from that observed at Wood Bay where females dominated in both years, both in the total sample (66-68%) and among spawning-sized fish (69-78%).

Typically, most Arctic cisco taken in 1991 were either juveniles or mature non-spawners. Overall, only 4.7% of males and 21.6% of females were considered capable of spawning in 1991. Among fish ≥330 mm (n = 346), 35.6% of females and 8.4% of males were determined to be current-year spawners. The proportion of current-year spawners in the Liverpool Bay samples exceeded that observed in either year at Wood Bay. Similarly to observations of previous years (Bond and Erickson 1987, 1991, 1992), current-year spawners were most common in early summer. Such individuals accounted for 43% of all fish ≥330 mm during July, but only 13% during August.

The gonadosomatic index (GSI) for spawning females (n = 62) ranged from 2.08 to 11.90. Mean GSI for spawning females was 4.25 in July, 8.03 in early August, and 7.90 in late

August (Table 9). Female Arctic cisco captured at spawning time in the lower Mackenzie River display a mean GSI exceeding 23.0 (range: 19.69-31.27) (J. Reist, Can. Dep. Fish. and Oceans, Winnipeg, pers. commun.). Fourteen male pre-spawners were identified in the Liverpool Bay samples, only one of which was captured after 15 August. GSI values for these fish ranged from 0.83 to 2.53. Within our aged sample, the youngest Arctic cisco capable of spawning in the current year were an age 9 male and an age 10 female (Table 7). During our three years of sampling in Wood Bay and Liverpool Bay, we observed no current-year spawners younger than age 9.

Food habits: Excluding age 0 fish, the stomachs of 640 Liverpool Bay Arctic cisco were examined, of which 340 (53%) contained no food. A detailed analysis of 150 of the remaining 300 stomachs (Table 10) indicated that Amphipoda and Isopoda occurred with the highest frequency and made important contributions to the total food biomass (9 and 10%), respectively. Fish (22%), Cumacea (10%), and Gastropoda (10%) also contributed significantly to the food biomass but occurred less frequently in the stomachs. In the case of Gastropoda, the total contribution was based on the consumption of a large number of Pteropoda by a single fish. Smaller fish (<250 mm) tended to have a less varied diet, and relied more heavily on Copepoda, Cumacea, and Insecta than did larger fish.

We also examined the stomachs of 92 age 0 cisco, 25 (27%) of which were empty. The diet of age 0 Arctic cisco was less varied than that of older, larger individuals as prey size became an important determinant. Copepoda, Insecta, and Cladocera were the principal foods, occurring in 61, 42, and 37%, respectively, of stomachs that contained food (Table 10). Copepoda dominated the diet numerically, accounting for 87% of all food items consumed. Young arriving in late July contained fewer food items (particularly fewer Copepoda) than those captured later in the summer. Insecta (Diptera) were relatively more important to these early arrivals, occurring in 74% of those stomachs containing food and contributing 20% of the diet in terms of numbers.

Tagging results: Because of equipment failure, Floy tags were applied to only eight Arctic cisco in 1991, bringing to 3291 the total number of cisco tagged during the three years of this study. To date (June 1993), only two recaptures have been reported. One fish, tagged 5 September 1989 in Wood Bay, was recaptured during summer 1991 in Tuktoyaktuk Harbour. The second, tagged 11 August 1990 in Wood Bay, was recaptured 23 July 1991 in Liverpool Bay. The current study also recovered several fish tagged by other studies, including four that were tagged by LGL personnel at McKinley Bay in 1988. One of these was recaptured in Wood Bay in 1990 while the others were recaptured in Liverpool Bay during 1991. An additional fish, tagged 27 August 1985 at Prudhoe Bay, Alaska (291 mm) was recaptured in Liverpool Bay on 21 August 1991 (417 mm). At least 1000 km of coastal habitat separate the tagging and recapture sites for this specimen. Although the data are sparse and inconclusive, the tag returns reported by this study indicate that Arctic cisco can occupy very widely separated parts of the Beaufort Sea coast in the course of their life history. They suggest as well that Arctic cisco of Wood Bay and Liverpool Bay, like those found along the Alaskan coast, represent Mackenzie River stocks.

Least cisco

Least cisco are less migratory than Arctic cisco and their distribution in coastal habitats tends to be more closely associated with the plume of their home river; this is particularly true in the case of young individuals (Craig 1984; Reist and Bond 1988). Because no major streams enter Liverpool Bay in the vicinity of our study area, it is not surprising that least cisco were not abundant in the 1991 trap net catch (n = 663) and that those captured were predominantly larger, older individuals. By comparison, the two-year catch of least cisco at Wood Bay was 95 439, of which approximately 90% were smaller than 180 mm in fork length (Bond and Erickson 1991, 1992).

Size distribution and seasonal abundance: Least cisco captured in the trap nets at Liverpool Bay ranged in fork length from 67 to 360 mm. Large least cisco (≥180 mm) accounted for 85% of the total species catch and produced two major peaks in the length-frequency distribution (Fig. 11). Fish in the range 170-229 mm are juvenile fish that accounted for 35% of all least cisco taken. Those in the 250-309 mm range made up 43% of the least cisco catch and represent the adult segment of the population.

Catch rates for large least cisco were similar at the two netting locations, averaging 7.3 fish$\cdot$d^{-1} at Station 601 and 6.5 fish$\cdot$d^{-1} at

Station 602 (Table 6). Gill nets set during the period 1-18 July captured only one least cisco, suggesting that few large least cisco were present in the study area prior to the beginning of trap netting. A small run of large fish moved through the study area between 26 July and 22 August, producing CPUE peaks of 17 fish • d^{-1} in Cycle 4 at Station 601 and 7 to 8 fish • d^{-1} in Cycles 4 to 6 at Station 602 (Fig. 12). Peak catches were much higher at Wood Bay in 1989 and 1990, where overall CPUE at the various trap locations ranged from 35 to 60 fish • d^{-1} (Bond and Erickson 1991, 1992).

Small least cisco (<180 mm) made up only 15% of the total species catch and were not abundant in the study area at any time during 1991 (Fig. 13). The overall CPUE was just 1.0 fish • d^{-1} at Station 601 and 1.6 fish • d^{-1} at Station 602 (Table 6). A small mode occurring at the 70-109 mm range in the length-frequency distribution (Fig. 11) consists of age 1 individuals.

Age and growth: Otolith age estimates for Liverpool Bay least cisco ranged from 0 to 17 years (Table 11). By inference from the length-frequency distribution (Fig. 11), most least cisco captured were either 4 to 5 or 7 to 12 years of age. Fish of the latter group represent the spawning segment of the population (≥250 mm). The mathematical relationship between fork length and body weight for least cisco captured in Liverpool Bay during 1991 (Table 8) is described by the equation:

$$\log_{10}W = 3.2990 (\log_{10}L) - 5.7756$$

Sex and maturity: As was the case in both years at Wood Bay, female least cisco out numbered males at Liverpool Bay, accounting for 60% of all least cisco for which sex was determined (n = 144). The male:female sex ratio of 0.67 was significantly different from unity ($X^2 = 5.44$; $P < 0.05$). Among individuals of potential spawning size (≥250 mm) (n = 89), 66% were females and the male:female ratio (0.51) again differed significantly from 1:1 ($X^2 = 9.45$; $P < 0.005$).

Current-year spawners were proportionately more abundant in our Liverpool Bay samples than in either year at Wood Bay (Bond and Erickson 1991, 1992). Overall, 57% of the females and 35% of the males examined were considered capable of spawning in 1991. Among fish ≥250 mm, 83% of females and 67% of males were current-year spawners. The higher proportion of current-year spawners in the 1991 Liverpool Bay catch compared with the 1989 and 1990 Wood Bay situation probably reflects the difference in sampling location relative to the overall coastal movement pattern of this species. Younger, smaller least cisco tend to remain closer to their river of origin while the longest coastal migrations are undertaken by the older, larger individuals. It is likely that our Liverpool Bay site was located far enough away from the home river as to be inaccessible to most small least cisco.

Gonadosomatic index values for female current-year spawners (n = 49) ranged from 2.54 to 11.71 with a mean of 6.93 (SD = 2.33). Mean GSI increased from 3.34 in July to 7.83 during late August (Table 9). In the Mackenzie River, GSI values of female least cisco can exceed 20.0 by the late September - early October spawning period (K. Chang-Kue, Can. Dep. Fish. and Oceans, Winnpeg, pers. commun.). Female pre-spawners captured in Wood Bay during late August and early September 1989 had GSI values ranging up to 19.40 (Bond and Erickson 1991). For male pre-spawners taken at Liverpool Bay (n = 20) the GSI ranged from 0.83 to 2.49 (Table 9). In 1991, the youngest least cisco judged capable of spawning during the current year were a 6-year-old male (232 mm) and a 7-year-old female (262 mm).

Food habits: The stomachs of 147 least cisco were examined during the present study, of which 74 (50%) were empty. With the exception of a few individuals, most fish with food contained only small amounts. A high incidence of empty stomachs, or of stomachs containing only small quantities of food, has been a common finding for least cisco captured on the Beaufort Sea coast (Jones and den Beste 1977; Kendel et al. 1975; Bond 1982; Lawrence et al. 1984). A laboratory analysis of 46 stomachs (Table 12) revealed the least cisco diet in Liverpool Bay to consist mainly of Crustacea as Isopoda, Copepoda, and Amphipoda accounted for 39, 15, and 12%, respectively, of the total food biomass. The high value for Copepoda was produced by a single fish whose stomach was completely filled with these small crustaceans. Adult insects were important in the early summer diet, occurring in 88% of the stomachs and contributing 22% of the food biomass during July. Insect material identified from the stomach contents included adult Diptera, Trichoptera, and Hymenoptera.

Other coregonids

Although they share a number of common features, many differences of detail are observed in the life history patterns of the five coregonid species that are important to fisheries in the Beaufort Sea region (Reist and Bond 1988). One of the most obvious differences between these species is in the degree of anadromy exhibited and the range of coastal habitats occupied. The following three species, broad whitefish, lake whitefish, and inconnu prefer lower salinities and, thus, tend to undertake less extensive coastal migrations than do Arctic cisco and least cisco. While abundant in the freshened waters of the Anderson River estuary (Bond and Erickson 1991, 1992), these three species made up less that 1.0% of the total trap net catch at our 1991 Liverpool Bay site. Whether the fish in question belong to the Anderson River populations or represent populations inhabiting streams flowing into Liverpool Bay (e.g., Kugaluk) is not known. It seems unlikely, however, that they would be of Mackenzie River origin.

Broad whitefish: Broad whitefish were caught in the traps on 37 of 45 netting days (82%). Abundance was low, however, as this species accounted for just 0.7% of total catch and 1.9% of all coregonids during the 1991 study (Tables 3 and 5). Apart from the period 29 July - 3 August, during which 65% of the total broad whitefish catch was made, daily catches exceeded four individuals on just five occasions. The relatively high catches occurring during this six-day period produced weekly CPUE values ranging from 4 to 15 fish$\cdot d^{-1}$ during Cycles 3 and 4 (Fig. 14). Overall catch rates for broad whitefish were 2 fish$\cdot d^{-1}$ at Station 601 and 5 fish$\cdot d^{-1}$ at Station 602 (Table 6).

Broad whitefish from the trap nets (n=278) ranged in fork length from 50 to 594 mm but the majority (72%) were smaller than 100 mm (Fig. 15). These small fish entered the study area during Cycle 3 and were primarily responsible for the relatively high CPUE values observed in Cycles 3 and 4. Of all broad whitefish taken between 29 July and 3 August, 90% were in the 50-79 mm size-range (age 0). Intermediate-sized fish (190-439 mm) were absent from our catches while individuals $\geq$ 440 mm accounted for 16% of the total. Half of these large fish were taken during Cycle 4 (2-8 August).

Broad whitefish catches at Liverpool Bay were dominated by age 0 individuals (50-99 mm). Small numbers of age 1 and age 2 fish were also taken while broad whitefish in the larger group ranged in age from 10 to 18 years. Age-groups 3 to 9, inclusive, were not represented in our sample (Table 13).

Sex was ascertained for 24 broad whitefish, 63% of which were females. The gonadosomatic index was determined for 13 fish, all of which were considered current-year spawners (Table 9). For females (n=9; 469-564 mm), GSI ranged from 4.42 to 13.75 with a mean of 7.66. Males (n=4; 471-582 mm) had GSI values ranging from 0.83 to 1.76 with a mean of 1.26. The youngest broad whitefish found to be capable of spawning during the current season were an age 10 male (471 mm) and an age 13 female (469 mm). During the three years of this study, the youngest broad whitefish identified as current-year spawners were age 9 (male) and age 13 (female).

Broad whitefish from Liverpool Bay showed no evidence of having fed recently. Of 24 stomachs examined, 21 (88%) were empty and the others contained only traces of food.

Lake whitefish: Lake whitefish occurred in the trap nets with a frequency of 78% (on 35 of 45 days), but daily catches exceeded two individuals on only eleven occasions. The largest daily catches were made on 28 July (n=8) and 22 August (n=12), resulting in CPUE peaks during Cycle 3 and Cycle 6 (Fig. 16). Overall, lake whitefish occurred in equal abundance (1 fish$\cdot d^{-1}$) at both trap net locations (Table 6).

Measured whitefish (n=92) varied in fork length from 247 to 516 mm with 75% of the sample falling in the 390-459 mm size-range (Fig. 17). An additional four specimens (402-479 mm) were taken in gill nets between 5 and 17 July. We captured only two lake whitefish smaller than 330 mm.

Based on a limited sample (n=53), otolith age estimates for Liverpool Bay lake whitefish ranged from 5 to 34 years (Table 14). Females out-numbered males in our sample, accounting for 57% of fish for which sex was determined (n=53). Most of the fish caught were either current-year spawners or mature non-spawners and few juveniles were taken. Twenty-three percent of the females and 48% of the males examined were considered to be current-year spawners. In addition, 10 females were identified as being previous spawners (age 9-28; fork length 370-475 mm).

Among females, GSI values for current-year spawners (n = 6) ranged from 3.66 to 12.09. Mean GSI for spawning females increased from 5.90 in July (n = 3) to 11.27 in late August (n = 2) (Table 9). For spawning males (n = 10), GSI values ranged from 1.42 to 3.78 with a mean of 2.26. The youngest lake whitefish considered to be capable of spawning in the current season were 10 (female) and 11 (male) years of age (Table 13). Over the three years of this study, the youngest current-year spawners identified were age 10 (both sexes). However, the occurrence at Liverpool Bay of a 9-year-old previous spawner, indicates that some individuals spawn as early as age 8 in this area.

The stomachs of 59 lake whitefish were examined, of which 41 (69%) were empty. The remaining stomachs contained food in small quantities only. Four stomachs examined in the laboratory contained a combined wet weight biomass of 1.74 g. Contributing to the food were Amphipoda (27%), Insecta (5%), Pelecypoda (2%), Isopoda (1%), and residual matter (65%).

Given the distance of the Liverpool Bay study area from the mouth of a major stream (Fig. 1), the results of the 1991 study were not unexpected. Mackenzie River lake whitefish are seldom caught in coastal habitats as age 0 fish, and juveniles up to age 4 remain closely associated with the Mackenzie Delta (Reist and Bond 1988). Older juveniles and adults tend to migrate farther, but abundance decreases rapidly with increasing distance from the river mouth (Kendel et al. 1975; Lawrence et al. 1984). A similar pattern was observed at Wood Bay, where larger fish contributed a larger proportion of the trap net catches with increasing distance from the mouth of the Anderson River (Bond and Erickson 1991, 1992).

Inconnu: Trap nets captured four inconnu (408-861 mm) at Liverpool Bay in 1991 and one additional specimen was taken in gill nets. Of three fish that were sacrificed, two were current-year spawners. One, a female captured 14 July (1001 mm; 10 451 g), had a GSI value of 3.90 while the other, a male taken 1 August (834 mm; 5793 g), had a GSI of 0.98 (Table 9). The stomachs of both fish were empty.

Populations of inconnu occur in the Mackenzie River and in the Anderson River but it is not known to which group the Liverpool Bay fish belong. Inconnu are not known to inhabit other coastal rivers such as the Kugaluk and Miner, and previous studies in Liverpool Bay have not reported their presence (Bray 1975; Gillman and Kristofferson 1984). Inconnu utilize coastal habitats for summer feeding (Kendel et al. 1975; Percy 1975; Bond and Erickson 1991, 1992); however, the coastal migrations of inconnu are the least extensive of the five anadromous coregonid species occurring in the southern Beaufort Sea region (Reist and Bond 1988).

Saffron cod

Although common and widely distributed along the Beaufort Sea coast, saffron cod seldom makes up more than 1.5% of the total catch in nearshore trap net studies (Moulton et al. 1985; Cannon et al. 1987; Bond and Erickson 1989). Results at Wood Bay fell within the usual range as this species accounted for 0.4 and 0.9% of the catch in 1989 and 1990, respectively (Bond and Erickson 1991, 1992). However, at Liverpool Bay in 1991, saffron cod appeared in unexpected abundance, accounting for 31% of total catch and 52% of all marine fish taken in the traps (Tables 3 and 5). Daily catches exceeded 500 fish on nine occasions during the summer, the highest count (n = 1724) occurring on 19 August.

Saffron cod began moving into the study area during Cycle 2 (19-25 July) and their abundance increased to a peak in Cycle 6 (16-22 August) when catch rates for the species averaged 417 fish$\cdot$d^{-1} at Station 601 and 311 fish$\cdot$d^{-1} at Station 602. For the study, CPUE averaged 168 fish$\cdot$d^{-1} at Station 601 and 126 fish$\cdot$d^{-1} at Station 602 (Table 6). Seasonal trends in CPUE were similar at the two sampling locations (Fig. 18).

Fork lengths were obtained for 1151 saffron cod. Lengths ranged from 85 to 475 mm but the length-frequency distribution (Fig. 19) was strongly bimodal, consisting primarily of individuals in the 200-249 mm size range (27%) or between 290 and 359 mm (49%). Cod smaller than 200 mm accounted for less than 4% of the measured sample. The relationship between body weight and fork length for saffron cod captured in Liverpool Bay during 1991 (Table 8) is described by the equation:

$$\log_{10}W = 2.9207 (\log_{10}L) - 5.0082$$

The tendency for saffron cod from trap net catches to produce distinct modes in the length-frequency distribution appears to be a common feature in samples taken on the Beaufort Sea coast. On the Yukon coast in 1986 (Bond and Erickson 1989), strong modes occurred at 240-259 mm and at 400-419 mm; 61% of this sample was in the 200-299 mm range and only 4% were smaller than 200 mm. At Wood Bay in 1989 (Bond and Erickson 1991), discrete modes were observed at 140-149 mm, 350-359 mm, and 410-419 mm; in this sample, only 4% of the fish were in the 200-299 mm size range while 50% were smaller than 200 mm. These modes often consist of fish of a single year-class. Otolith analysis of Yukon coastal saffron cod mentioned above showed the smaller mode to consist almost exclusively of age 3 fish while the larger mode was comprised mainly of 7-year-olds (J. Johnson, Can. Dep. Fish. and Oceans, Winnipeg, pers. commun.). This type of pattern suggests that saffron cod in the Beaufort Sea commonly produce very strong year-classes followed by one or more weak year-classes.

Pacific herring

Pacific herring of the Beaufort Sea spawn around the time of ice breakup (late June) in the deep coastal bays in which they have overwintered. Following spawning, they disperse widely throughout the southern Beaufort Sea for foraging. The return migration to the overwintering sites begins in late August. Immature herring accompany the mature fish to and from the overwintering sites, but the summer feeding areas of adults and juveniles may or may not coincide (Bond 1982). The "fingers" area of Liverpool Bay is known to be a major spawning and overwintering site for Pacific herring (Gillman and Kristofferson 1984).

Pacific herring accounted for 2.4% of the total catch at Liverpool Bay in 1991 and was third in abundance among marine species taken in the trap nets (Tables 3 and 5). Although present throughout the summer, herring generally yielded low catch rates (<10 fish$\cdot$d^{-1}) until the final week of sampling when CPUE rose to 105 fish$\cdot$d^{-1} at Station 601 and 32 fish$\cdot$d^{-1} at Station 602 (Fig. 20). Overall catch rates were similar at the two sampling sites (Table 6).

Fork lengths for Pacific herring ranged from 58 to 305 mm but most individuals were either 140-199 mm (70%) or 240-279 mm (17%) (Fig. 21). Fish in the larger size-group are thought to represent the spawning population based on an analysis of 45 herring captured in gill nets between 14 and 24 July. Of this number, 41 (23♂:18♀) were spent fish ranging between 234 and 321 mm in fork length (modal length 280-289 mm). Just one of these spent fish was smaller than 250 mm. Most herring larger than 250 mm fork length were considered sexually mature in Tuktoyaktuk Harbour (Bond 1982). In a study of the Liverpool Bay spawning population, Gillman and Kristofferson (1984) reported most fish in their gill netted sample to be 270-309 mm (standard length).

The length-frequency distribution for Pacific herring at Liverpool Bay in 1991 differed markedly from that observed at Wood Bay in 1989 (Bond and Erickson 1991). In that study, the trap net catch was dominated by individuals in the 70-99 mm size-range (thought to be age 2) and just 0.6% exceeded a fork length of 149 mm. This suggests that small juvenile herring may range less widely during the summer foraging period than do large juveniles or adults, or at least exploit different habitats.

Rainbow smelt

The Mackenzie River provides the only known spawning habitat in the Canadian Beaufort Sea area for rainbow smelt. Spawning occurs just prior to spring break-up (Percy 1975) and the spent adults then leave the river to forage in coastal waters. Newly-emerged smelt fry drift to the Mackenzie estuary on the spring flood, dispersing to at least Phillips Bay on the Yukon coast (Bond and Erickson 1989) and as far as McKinley Bay on the Tuktoyaktuk Peninsula (Lawrence at al. 1984). Both adults and juveniles overwinter in the sea.

Rainbow smelt accounted for 2.5% of the total trap net catch in 1991 (Tables 3 and 5). CPUE was higher overall at Station 602 (17 fish$\cdot$d^{-1}) than at Station 601 (8 fish$\cdot$d^{-1}) (Table 6). Early season gill netting (1-18 July) took no rainbow smelt and none was captured in the traps until 24 July when two were taken at Station 601. Smelt moved into the study area during Cycle 3 (26 July - 1 August), producing abundance peaks of 47 fish$\cdot$d^{-1} at Station 602 in Cycle 4 and 19 fish$\cdot$d^{-1} at Station 601 in Cycle 5. By late August, CPUE had dropped again to low levels indicating that smelt had left the study area (Fig. 22).

Rainbow smelt from the trap nets had fork lengths ranging from 68 to 302 mm, but catches were dominated by fish between 170 and 259 mm which comprised 78% of the measured sample (Fig. 23). Fish of this size probably represent the spawning segment of the population. Smelt were not measured at Wood Bay in 1990, but in 1989, trap net catches were dominated by juvenile fish in the 60-119 mm size-range and individuals larger than 200 mm contributed just 2% of the total sample (Bond and Erickson 1991).

We captured no age 0 smelt in either Wood Bay or Liverpool Bay, but small numbers of age 1 fish were taken in seines at both locations. In 1991, 12 smelt, considered to be age 1 on the basis of length (Bond and Erickson 1989), were captured between 1 July and 23 July. Measurement of six individuals showed a mean fork length of 35.0 ± 2.3 mm (range: 32-39 mm) and a mean weight of 0.09 ± 0.03 g (range: 0.07-0.14 g).

Arctic flounder

Recent trap netting studies have shown Arctic flounder to be much more abundant in Canadian Beaufort Sea coastal waters than previously thought. After overwintering in offshore marine areas, flounder invade nearshore habitats shortly after breakup, returning to deeper water later in the summer. These inshore movements, presumably for feeding, appear to be most pronounced in the vicinity of river mouths (Bond and Erickson 1989, 1991, 1992).

Perhaps because of the absence of a major nearby river, Arctic flounder was less abundant at our Liverpool Bay location than has been observed in previous studies. However, this species was still third in overall abundance, accounting for 24% of the total catch and 41% of marine fish taken in the trap nets (Tables 3 and 5).

Arctic flounder entered the Liverpool Bay study area in large numbers toward the end of July, remaining abundant in the catches until Cycle 7 (23-29 August) when a sharp decrease in CPUE suggested a return to deeper water (Fig. 24). Although seasonal trends were similar at the two sampling locations, higher overall catch rates were recorded at Station 601 (142 fish $\cdot$ d^{-1}) than at Station 602 (88 fish $\cdot$ d^{-1}) (Table 6). Comparable catch rates at Wood Bay ranged from 201 to 449 fish $\cdot$ d^{-1} (Bond and Erickson 1991, 1992).

Arctic flounder from the trap nets were not measured during 1991; however, 21 individuals taken in gill nets ranged in total length from 67 to 298 mm.

Fourhorn sculpin

Fourhorn sculpin is one of the most common marine fish captured in Beaufort coastal waters where it provides important forage for many species (Kendel et al. 1975; Galbraith and Hunter 1975; Griffiths et al. 1975, 1977; Lawrence et al. 1984). Fourhorn sculpin made up 1% of the total trap net catch at Liverpool Bay in 1991 (Tables 3 and 5), but this species was not as abundant as at Wood Bay (Bond and Erickson 1991, 1992). Excluding the most freshened location, overall CPUE values by trap site ranged from 27 to 34 fish $\cdot$ d^{-1} at Wood Bay while at Liverpool Bay, the value was 5 fish $\cdot$ d^{-1} at both sampling locations (Table 6). The seasonal abundance trend was also similar at both Liverpool Bay locations with CPUE peaking between 2-15 August, then declining over the remainder of the sampling period (Fig. 25).

Although fourhorn sculpin were not routinely measured during 1991, 27 fish captured in gill nets ranged in total length from 145 to 456 mm. The 456 mm fish, which weighed 1024 g is, to the best of our knowledge, the largest individual of this species ever reported from the Beaufort Sea.

Other species

Apart from those discussed above, several fish species captured in Liverpool Bay are of interest, either because of their limited distribution or because they have not been commonly reported by studies on the Beaufort Sea coast.

Greenland cod (ogac): In Canada the Greenland cod occurs from Nova Scotia north to Baffin Island, throughout Hudson Strait and Hudson Bay, and westward along the mainland coast to the Beaufort Sea (Hunter et al. 1984; Scott and Scott 1988). The species does not appear to be abundant in the Beaufort Sea where capture records are limited to the area east of the Mackenzie River (Hunter et al. 1984); however, Anderson (1913) reported them as being "locally abundant" in Liverpool Bay. In the northern part of its range, the ogac is usually found inshore (Scott and Scott 1988) and seems to prefer embayments and inlets over the open coast (Mikhail and Welch 1989; H.E. Welch, Can. Dep. Fish. and Oceans, Winnipeg, pers. commun.). The life history and general biology of Greenland cod are poorly known although ogac inhabiting Saqvaqjuac Inlet on the northwest coast of Hudson Bay have been described as being demersal, non-schooling, slow growing, top carnivores without apparent significance to marine mammal or bird food webs (Mikhail 1985; Mikhail and Welch 1989). Greenland cod has no current commercial value but is used by the Inuit in some areas primarily as dog food (Crawford 1989).

Greenland cod were not captured at Liverpool Bay prior to 31 July but occurred regularly in the catch throughout August at salinities ranging from about 6 to 13 g • kg^{-1}. A total of 48 Greenland cod were taken in the trap nets (Tables 3 and 5) while an additional eight specimens were caught in gill nets. These cod ranged in fork length from 127 to 430 mm with 75% of the measured sample (n = 53) being in the 160-229 mm size-range. The largest cod taken (430 mm) had a body weight of 850 g.

Pacific sand lance: In North America, the Pacific sand lance (*A. hexapterus*) is distributed from southern California to Alaska and the Bering Sea (Hart 1973). It is common but apparently not abundant in Beaufort Sea coastal waters of Alaska (Moulton et al. 1985; Cannon et al. 1987; Palmer and Dugan 1990) and Canada (Galbraith and Hunter 1975; Jones and den Beste 1977; Bond and Erickson 1987). It has been reported from as far east as Cambridge Bay in the Canadian central arctic (Hunter et al. 1984). Currently, the Pacific sand lance is distinguished taxonomically from the American sand lance (*A. americanus*) which occurs from Hudson Bay to Labrador and south along the Atlantic coast to Virginia (Robins et al. 1991). Sand lance are an important food chain organism, being consumed by other species of fish, marine mammals, sea birds, and invertebrates (Hart 1973; Scott and Scott 1988). They have been reported from the stomach contents of Arctic cisco on the Yukon coast (Bond and Erickson 1987).

Forty-seven Pacific sand lance were captured in the trap nets at Liverpool Bay during the current study (Tables 3 and 5). The majority (94%) were taken during the month of August with the largest catches occurring on 3 August (n = 8), 27 August (n = 12), and 29 August (n = 13). Fork lengths (n = 15) ranged from 106 to 151 mm with a mean of 122 ± 12.8 mm. The two largest individuals (151 and 143 mm) weighed 10 and 8 g, respectively.

Blackline prickleback: Although of no economic importance, the blackline prickleback holds considerable scientific significance owing to its unique distributional pattern. The species occurs as three disjunct populations in the North Pacific and Arctic oceans, which future taxonomic study may reveal to be distinct species or sub-species (Houston and McAllister 1990). Its known Arctic distribution is limited to the Canadian Beaufort Sea where, until recently, it had been reported only from Tuktoyaktuk Harbour and Liverpool Bay (Galbraith and Hunter 1975; Hopky and Ratynski 1983; Ratynski 1983; Hunter et al. 1984). Bond and Erickson (1989) found the species at Phillips Bay on the Yukon coast but there has been no report to date of its occurrence in the Alaskan Beaufort Sea. During the three years of this study, we captured 1988 blackline prickleback in trap nets, most of which (n = 1753) were taken at Wood Bay in 1990. Although they have been reported to be non-schooling (Shchetinnikov 1983), our total in 1990 included 901 individuals caught overnight in one trap (Bond and Erickson 1992).

During 1991, 38 blackline prickleback were captured in trap nets in Liverpool Bay (Tables 3 and 5). All were taken between 29 July and 29 August, at salinities ranging from 8 to 12 g • kg^{-1}. Total lengths of 34 measured individuals ranged from 214 to 341 mm with a mean of 263 ± 29.6 mm.

Starry flounder: The starry flounder is widely distributed in coastal areas of the Pacific and Arctic oceans. Although found mainly in shallow, brackish waters, it has been captured at depths greater than 275 m and frequently enters streams (Orcutt 1950; Nikolski 1961). The Canadian Arctic distribution of starry flounder extends eastward to Bathurst Inlet (Hunter et al. 1984) but they appear to be most common near Tuktoyaktuk (Bond 1982; Lawrence et al. 1984). This species has been captured in small numbers near Prudhoe Bay (Glass et al. 1987), but most studies conducted in nearshore habitats along the Yukon-Alaska coast have failed to report its presence (Griffiths et al. 1975, 1977; Craig and Haldorson 1981; Moulton et al. 1985; Cannon et al. 1987; Bond and Erickson 1987, 1989; Frugé et al. 1989; Palmer and Dugan 1990).

In 1991, 57 starry flounder were captured in trap nets at Liverpool Bay (Tables 3 and 5) and an additional three were taken in gill nets. Total lengths for five measured fish ranged from 108 to 410 mm, the largest weighing 1108 g. A total of 823 starry flounder were taken at Wood Bay during the previous two summers (Bond and Erickson 1991, 1992).

Arctic sculpin: This species inhabits shallow coastal waters from the Gulf of St. Lawrence to Ungava Bay and westward to the Beaufort Sea (Dunbar and Hildebrand 1952; Hunter et al. 1984). Substantial catches of Arctic sculpin were reported near Kaktovik (Frugé et al. 1989; Palmer and Dugan 1990; Underwood et al. 1992) (n = 75, 187 and 605, respectively), and Baker (1985) reported it from Herschel Island. However, the species is apparently not common, appearing infrequently in catches along the Beaufort Sea coast.

Arctic sculpin was not taken in Wood Bay (Bond and Erickson 1991, 1992); however, we captured 11 specimens at Liverpool Bay in 1991, four in trap nets (Tables 3 and 5) and seven in gill nets. Total lengths for 10 measured individuals ranged from 123 to 220 mm and body weights for these fish varied from 23 to 172 g. All were captured between 31 July and 28 August at salinities ranging from 6 to 12 $g \cdot kg^{-1}$

Arctic staghorn sculpin: This sculpin has a distribution similar to that of the Arctic sculpin and has been documented from as far north as Eureka, NWT (Hunter et al. 1984). In the Beaufort Sea, staghorn sculpin has been reported from nearshore habitats (Frugé et al. 1989; Palmer and Dugan 1990; Underwood et al. 1992) but the species appears to be more abundant offshore (Galbraith and Hunter 1975; Chiperzak et al. 1990). Dunbar and Hildebrand (1952) reported staghorn sculpin to be most common at depths greater than 30 m.

Arctic staghorn sculpin was not captured during two years of sampling in Wood Bay but a single specimen was taken in Liverpool Bay in 1991. This individual was captured by gill net on 7 August at a depth of 5 m and salinity of 8.1 $g \cdot kg^{-1}$. Total length was 172 mm and body weight was 57 g.

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Table 1. Inclusive dates for sampling cycles referred to in this report and amount of fishing effort (days) at each trap by cycle, Liverpool Bay, 1991[1].

		Fishing Effort (d)			
		Station 601		Station 602	
Cycle	Date	Side 1	Side 2	Side 1	Side 2
1	12 July to 18 July	1.54	1.54	ND	ND
2	19 July to 25 July	3.85	3.85	ND	ND
3	26 July to 01 August	6.74	6.80	6.89	6.93
4	02 August to 08 August	6.96	6.99	6.97	6.93
5	09 August to 15 August	6.92	6.95	6.93	6.99
6	16 August to 22 August	7.01	7.01	7.02	7.02
7	23 August to 29 August	7.11	6.96	6.95	6.94
8	30 August to 01 September	2.96	3.05	2.98	2.97
Total	(days)	43.08	43.15	37.74	37.77
	(hours)	1034.0	1035.6	905.7	906.5

[1]Side 1 refers to the left codend as viewed from offshore.

Table 2. Scientific and common names[1] of fishes captured at Liverpool Bay, 1991.

Scientific Name	Common Name	Code
Family Clupeidae		
Clupea pallasi Valenciennes	Pacific herring	PCHR
Family Salmonidae		
Coregonus autumnalis (Pallas)	Arctic cisco	ARCS
Coregonus sardinella Valenciennes	Least cisco	LSCS
Coregonus clupeaformis (Mitchill)	Lake whitefish	LKWT
Coregonus nasus (Pallas)	Broad whitefish	BDWT
Stenodus leucichthys (Güldenstadt)	Inconnu	INCO
Salvelinus alpinus (Linnaeus)	Arctic char	CHAR
Family Osmeridae		
Osmerus mordax (Mitchill)	Rainbow smelt	RNSM
Mallotus villosus (Müller)	Capelin	CPLN
Family Gadidae		
Eleginus gracilis (Tilesius)	Saffron cod	SFCD
Boreogadus saida (Lepechin)	Arctic cod	ARCD
Gadus ogac Richardson	Greenland cod	GLCD
Family Gasterosteidae		
Pungitius pungitius (Linnaeus)	Ninespine stickleback	NSSB
Family Stichaeidae		
Acantholumpenus mackayi (Gilbert)	Blackline prickleback[2]	BLPB
Family Ammodytidae		
Ammodytes hexapterus Pallas	Pacific sand lance	PCSN
Family Cottidae		
Myoxocephalus quadricornis (Linnaeus)	Fourhorn sculpin	FHSC
Myoxocephalus scorpioides (Fabricius)	Arctic sculpin	ARSC
Gymnocanthus tricuspis (Reinhardt)	Arctic staghorn sculpin[3]	ASSC
Family Pleuronectidae		
Pleuronectes glacialis Pallas	Arctic flounder	ARFL
Platichthys stellatus (Pallas)	Starry flounder	STFL

[1] From Robins et al. (1991) except as noted.
[2] Common name recommended by Legendre et al. (1975).
[3] Single specimen captured in gill net.

Table 3. Total catch and species composition in trap nets, Liverpool Bay, 1991.

Species	Number Captured	Percent of Total Catch	Percent of Anadromous Catch
Anadromous			
Arctic cisco	13977	35.8	87.3
Least cisco	663	1.7	4.1
Broad whitefish	282	0.7	1.8
Lake whitefish	93	0.2	0.6
Rainbow smelt	989	2.5	6.2
Inconnu	4	<0.1	<0.1
Arctic char	3	<0.1	<0.1
Marine			
Saffron cod	12007	30.8	
Arctic flounder	9469	24.3	
Pacific herring	923	2.4	
Fourhorn sculpin	389	1.0	
Blackline prickleback	38	0.1	
Starry flounder	57	0.1	
Arctic cod	7	<0.1	
Capelin	3	<0.1	
Greenland cod	48	0.1	
Pacific sand lance	47	0.1	
Arctic sculpin	4	<0.1	
Freshwater			
Ninespine stickleback	2	<0.1	
Total	39005		

Table 4. Weekly contribution by coregonids to total trap net catch at each sampling station.

Cycle	Station 601		Station 602	
	Total Catch	Percent Coregonids	Total Catch	Percent Coregonids
1	171	89.5	ND	ND
2	1830	93.6	ND	ND
3	3677	57.8	6181	83.6
4	3255	22.6	2790	27.8
5	2988	14.5	2144	24.6
6	4961	4.1	3969	13.1
7	3808	38.7	1537	57.6
8	840	13.9	854	22.4
Total	21530	32.3	17475	46.2

Table 5. Distribution of 1991 trap net catch by station and codend[1].

Species	Station 601 Side 1	Station 601 Side 2	Station 601 Total	Station 602 Side 1	Station 602 Side 2	Station 602 Total	Grand Total
Large Arctic cisco	2403	2977	5380	2604	383	2987	8367
Small Arctic cisco	66	1004	1070	159	4381	4540	5610
Large least cisco	217	100	317	178	67	245	562
Small least cisco	17	24	41	19	41	60	101
Broad whitefish	31	60	91	10	181	191	282
Lake whitefish	7	40	47	8	38	46	93
Rainbow smelt	157	196	353	463	173	636	989
Inconnu	2	2	4				4
Arctic char		1	1	2		2	3
Arctic flounder	1423	4709	6132	1841	1496	3337	9469
Pacific herring	63	431	494	280	149	429	923
Fourhorn sculpin	110	106	216	95	78	173	389
Saffron cod	2675	4576	7251	3293	1463	4756	12007
Blackline prickleback	12	22	34	3	1	4	38
Starry flounder	9	21	30	18	9	27	57
Arctic cod	4	3	7				7
Capelin		2	2		1	1	3
Greenland cod	10	16	26	16	6	22	48
Pacific sand lance	27	3	30	14	3	17	47
Arctic sculpin	2	2	4				4
Ninespine stickleback				1	1	2	2
Total	7235	14295	21530	9004	8471	17475	39005

[1] Side 1 refers to the left codend as viewed from offshore.

Table 6. Overall CPUE (number $\cdot d^{-1}$) for the major fish species by station and codend[1].

Species	Station 601 Side 1	Station 601 Side 2	Station 601 Combined	Station 602 Side 1	Station 602 Side 2	Station 602 Combined
Large Arctic cisco	55.8	69.0	124.8	69.0	10.1	79.1
Small Arctic cisco	1.5	23.3	24.8	4.2	116.0	120.2
Large least cisco	5.0	2.3	7.3	4.7	1.8	6.5
Small least cisco	0.4	0.6	1.0	0.5	1.1	1.6
Broad whitefish	0.7	1.4	2.1	0.3	4.8	5.1
Lake whitefish	0.2	0.9	1.1	0.2	1.0	1.2
Inconnu	<0.1	<0.1	0.1			
Arctic flounder	33.0	109.1	142.1	48.8	39.6	88.4
Rainbow smelt	3.6	4.5	8.1	12.3	4.6	16.9
Fourhorn sculpin	2.6	2.5	5.1	2.5	2.1	4.6
Pacific herring	1.5	10.0	11.5	7.4	3.9	11.3
Saffron cod	62.1	106.0	168.1	87.3	38.7	126.0
Starry flounder	0.2	0.5	0.7	0.5	0.2	0.7

[1] Side 1 refers to the left codend as viewed from offshore.

Table 7. Mean fork length (mm), mean weight (g), mean condition factor (K), sex ratio and maturity by age-group for Arctic cisco at Liverpool Bay, 1991.

Otolith Age (yr)	Number of Fish	Fork Length Mean	Fork Length SD	Fork Length Range	Weight Mean	Weight SD	Weight Range	Mean Condition Factors (K)	Males n	Males % Spawners	Females n	Females % Spawners	Number Sex Unknown
0	50[1]	60	4.9	049-074	1	0.5	001-0003	0.57					50
1	29	99	8.7	078-118	9	1.9	004-0012	0.86					29
2	32	144	7.1	127-160	25	3.8	019-0033	0.85	9	0	13	0	10
3	43	178	9.3	162-196	43	7.9	031-0062	0.77	11	0	9	0	23
4	61	225	16.3	199-260	99	24.2	060-0163	0.86	28	0	24	0	9
5	22	270	8.1	257-289	181	20.3	146-0225	0.92	14	0	7	0	1
6	25	293	10.8	268-310	239	28.8	186-0289	0.95	12	0	11	0	2
7	8	316	4.1	312-321	301	15.0	278-0325	0.96	6	0	2	0	
8	14	329	7.4	315-343	347	35.6	273-0389	0.97	9	0	5	0	
9	10	348	5.5	342-362	409	45.6	360-0514	0.97	6	33	4	0	
10	21	363	15.8	347-396	471	95.1	356-0730	0.98	12	17	9	56	
11	18	374	14.8	350-398	529	86.0	401-0685	1.01	10	30	8	63	
12	18	385	13.1	354-401	586	84.6	407-0693	1.03	5	40	13	69	
13	9	403	19.8	370-444	647	160.3	447-0994	0.98	3	0	6	33	
14	6	409	7.4	402-421	761	58.5	703-0837	1.11			6	100	
15	7	416	9.8	399-425	789	59.9	716-0890	1.10			7	100	
16	7	415	8.9	405-427	717	121.4	509-0863	1.01	2	50	5	40	
17	3	428	1.5	427-430	890	10.1	884-0902	1.13			3	67	
18	3	442	12.0	430-454	836	208.3	602-1001	0.96			3	33	
19													
20	1	460			1258			1.29			1	100	
Total	387								127		136		124

[1] Captured 28 July; aged by length-frequency with 10 verified by otolith.

Table 8. Weight-length regressions for some fish species captured in Liverpool Bay, 1991.

Species	n	Length Range(mm)	Slope (b)	Intercept (a)	Std. Error of Est. (b)	Std. Error of Est. (a)	R^2
Arctic cisco	952	49-460	3.2657	-5.6879	0.0075	0.0174	0.9950
Least cisco	185	53-360	3.2990	-5.7756	0.0223	0.0516	0.9917
Saffron cod	172	196-415	2.9207	-5.0082	0.0491	0.1229	0.9542
Pacific herring	82	169-327	3.1269	-5.3488	0.0512	0.1240	0.9790

Table 9. Comparison of Gonadosomatic Index data by species, sex, and maturity category, Liverpool Bay, 1991[1].

Species/Category	July			1-15 August			16 August - 1 September		
	No. Examined	GSI Mean	GSI Range	No. Examined	GSI Mean	GSI Range	No. Examined	GSI Mean	GSI Range
Arctic cisco (≥330 mm)									
Females									
Spawners	59(57)	4.25	(2.08-6.97)	2	8.03	(7.59-8.47)	3	7.90	(4.69-11.90)
Non-spawners	77(69)	0.82	(0.24-1.82)	5	1.49	(0.61-2.25)	34(33)	1.32	(0.23-3.13)
Males									
Spawners	8	1.08	(0.83-1.60)	5	1.67	(1.00-2.53)	1	1.49	
Non-spawners	123(60)	0.42	(0.19-0.81)	8(2)	0.24	(0.23-0.25)	21(10)	0.37	(0.21-0.73)
Least cisco (≥250 mm)									
Females									
Spawners	4	3.34	(2.54-3.80)	18	6.37	(3.35-11.11)	27	7.83	(3.95-11.71)
Non-spawners	6(1)	1.62		1	2.85		3(1)	0.41	
Males									
Spawners	5	1.51	(1.11-1.88)	6	1.32	(0.93-2.49)	9	1.07	(0.83-1.64)
Non-spawners	4(2)	0.58	(0.53-0.62)	3(2)	0.53	(0.42-0.63)	3(1)	0.57	
Broad whitefish (≥425 mm)									
Females									
Spawners	4	6.78	(5.41-7.83)	2	5.64	(4.42-6.86)	3	10.19	(5.71-13.75)
Non-spawners	0			0			0		
Males									
Spawners	3	1.09	(0.83-1.23)	1	1.76		0		
Non-spawners	0			0			0		
Lake whitefish (≥375 mm)									
Females									
Spawners	3	5.90	(3.66-9.60)	1	8.81		2	11.27	(10.45-12.09)
Non-spawners	1	1.77		5	1.91	(0.65-2.96)	13	1.14	(0.32-1.78)
Males									
Spawners	2	1.77	(1.42-2.12)	2	1.69	(1.54-1.84)	6	2.61	(1.65-3.78)
Non-spawners	5(3)	0.37	(0.27-0.57)	2(1)	0.25		6(1)	0.24	
Inconnu (≥500 mm)									
Females									
Spawners	1	3.90		0			0		
Non-spawners	0			0			0		
Males									
Spawners	0			1	0.98		0		
Non-spawners	0			0			0		

…ntheses indicate sample size for GSI calculations where all fish not used. Where not used, gonad weight was <1 g. All fish were selected from size ranges … juveniles.

Table 10. Food habits of Arctic cisco captured at Liverpool Bay, 1991. Results are presented as percentage frequency of occurrence (FO), percentage wet weight (Wt), or percentage number (No.) for individuals in three size categories.[1]

	Size Category (Excl. Age 0)						Age 0 (50-74 mm FL)		
	≥250 mm FL		75-249 mm FL		Combined				
Food Item	FO	Wt	FO	Wt	FO	Wt	FO	No.	Mean Number per Stomach
Isopoda	65	10	27	10	47	10	1	1	0.6
Amphipoda	70	9	43	10	57	9	12	1	0.7
Copepoda	25	6	39	13	31	6	61	87	67.3
Cumacea	16	10	11	19	14	10			
Mysidacea	9	1	1	<1	5	1	4	<1	0.1
Cladocera							37	9	7.1
Pelecypoda	8	1			4	1			
Gastropoda	1	11			1	10			
Polychaeta	11	7	4	6	8	7			
Insecta	29	2	57	43	42	3	42	2	1.4
Ascidiacea	3	5			1	5			
Arachnida	1	<1	1	<1	1	<1			
Fish	20	23	4	2	13	22			
Plant Material	21	1	6	<1	14	1			
Residue	90	14	23	17	59	15			
No. stomachs analyzed	80		70		150		67		
Total wet weight of stomach contents (g)	76.06		3.62		79.68		ND		

[1] Based on laboratory analyses and including only those stomachs that contained food.

Table 11. Mean fork length (mm), mean weight (g), mean condition factor (K), sex ratio and maturity by age-group for least cisco at Liverpool Bay, 1991.

Otolith Age (yr)	Number of Fish	Fork Length Mean	Fork Length SD	Fork Length Range	Weight Mean	Weight SD	Weight Range	Mean Condition Factors (K)	Males n	Males % Spawners	Females n	Females % Spawners	Number Sex Unknown
0	6	71	2.3	067-074	2	0.5	001-002	0.47					6
1	8	92	9.3	076-101	5	1.5	003-007	0.67					8
2	10	137	12.1	118-153	20	6.7	011-031	0.76	1	0	3	0	6
3	4	166	5.9	159-171	33	3.1	030-037	0.72	3	0	1	0	
4	22	183	7.9	163-195	49	9.5	027-065	0.80	15	0	7	0	
5	19	210	12.7	185-240	76	15.0	052-108	0.81	6	0	13	0	
6	10	241	13.4	223-260	122	27.8	086-159	0.86	5	40	4	0	1
7	10	268	4.0	262-274	173	14.0	158-197	0.90	4	50	6	33	
8	7	275	5.6	263-280	187	19.8	153-208	0.90	3	67	4	75	
9	14	284	8.0	269-305	213	34.7	162-305	0.92	7	57	7	71	
10	31	301	13.5	278-324	256	44.5	177-342	0.93	9	89	22	95	
11	7	310	10.3	299-329	304	64.2	228-427	1.01			7	100	
12	9	312	15.8	283-330	267	51.1	184-339	0.87	3	67	6	83	
13	1	330			289			0.80			1	100	
14	2	339	12.7	330-348	377	101.8	305-449	0.96			2	100	
15	2	351	4.2	348-354	461	32.5	438-484	1.07			2	100	
16													
17	1	360			462			0.99			1	100	
Total	163								56		86		21

Table 12. Percentage frequency of occurrence (FO) and percentage wet weight (Wt) for major components of the diet of least cisco at Liverpool Bay, 1991[1].

	July		August		Total	
Food Item	FO	Wt	FO	Wt	FO	Wt
Isopoda	80	45	48	31	65	39
Insecta	88	22	48	3	70	14
Amphipoda	72	15	43	9	59	12
Copepoda	28	<1	48	37	37	15
Mysidacea	8	<1	10	<1	9	<1
Plant Matter	84	<1	38	<1	61	<1
Residue	100	17	95	21	98	19
No. stomachs analyzed	25		21		46	
Total wet weight of stomach contents (g)	10.49		6.97		17.46	

[1] Based on laboratory analyses and including only those stomachs that contained food.

Table 13. Mean fork length (mm), mean weight (g), mean condition factor (K), sex ratio and maturity by age-group for broad whitefish at Liverpool Bay, 1991.

Otolith Age (yr)	Number of Fish	Fork Length Mean	Fork Length SD	Fork Length Range	Weight Mean	Weight SD	Weight Range	Mean Condition Factors (K)	Males n	Males % Spawners	Females n	Females % Spawners	Number Sex Unknown
0[1]	35	64	5.2	054-076									35
0[2]	15	83	8.7	068-096	5	1.8	0002-0009	0.81					15
1	18	149	8.9	135-165	35	7.3	0024-0049	1.03	3	0	4	0	11
2	4	178	6.2	172-186	60	6.6	0053-0069	1.07	2	0	2	0	
3													
4													
5													
6													
7													
8													
9													
10	1	471			1466			1.40	1	100			
11													
12													
13	1	469			1360			1.32			1	100	
14													
15	1	477			1530			1.41			1	100	
16	1	498			1558			1.26			1	100	
17	2	512	11.3	504-520	2030	142.8	1929-2131	1.52			2	100	
18	2	538	9.9	531-545	2193	166.2	2075-2310	1.41			2	100	
Total	80								6		13		61

[1] Captured 29-30 July; aged by length-frequency.
[2] Captured 13-28 August; aged by otolith.

Table 14. Mean fork length (mm), mean weight (g), mean condition factor (K), sex ratio and maturity by age-group for lake whitefish at Liverpool Bay, 1991.

Otolith Age (yr)	Number of Fish	Fork Length Mean	Fork Length SD	Fork Length Range	Weight Mean	Weight SD	Weight Range	Mean Condition Factors (K)	Males n	Males % Spawners	Females n	Females % Spawners	Number Sex Unknown
5	1	261			169			0.95			1	0	
6													
7	2	369	2.1	367-370	551	33.9	527-0575	1.10			2	0	
8	1	357			445			0.98			1	0	
9	2	384	19.1	370-397	583	58.7	541-0624	1.04			2	0	
10	1	404			736			1.12			1	100	
11	6	397	8.0	386-404	641	77.5	509-0719	1.02	4	25	2	0	
12	7	401	6.3	391-409	658	39.3	605-0735	1.02	5	60	2	0	
13	1	429			829			1.05	1	0			
14	9	416	8.9	407-431	744	63.0	662-0860	1.03	4	25	5	0	
15	2	431	22.6	415-447	884	26.9	865-0903	1.11			2	50	
16	3	434	19.1	416-454	872	80.1	821-0964	1.07	1	100	2	0	
17	3	433	1.0	432-434	861	80.4	803-0953	1.06	2	0	1	0	
18	4	441	13.3	423-455	865	84.3	744-0933	1.01	3	33	1	0	
19	1	445			899			1.02			1	0	
20													
21	1	452			1030			1.12	1	100			
22	1	422			820			1.09			1	100	
23													
24	1	459			999			1.03			1	0	
25	1	490			1225			1.04			1	100	
26	3	465	12.2	457-479	1038	46.3	988-1079	1.03	2	50	1	100	
28	1	475			1248			1.16			1	0	
31	1	499			1228			0.99	1	100			
34	1	516			1623			1.18			1	100	
Total	53								24		29		0

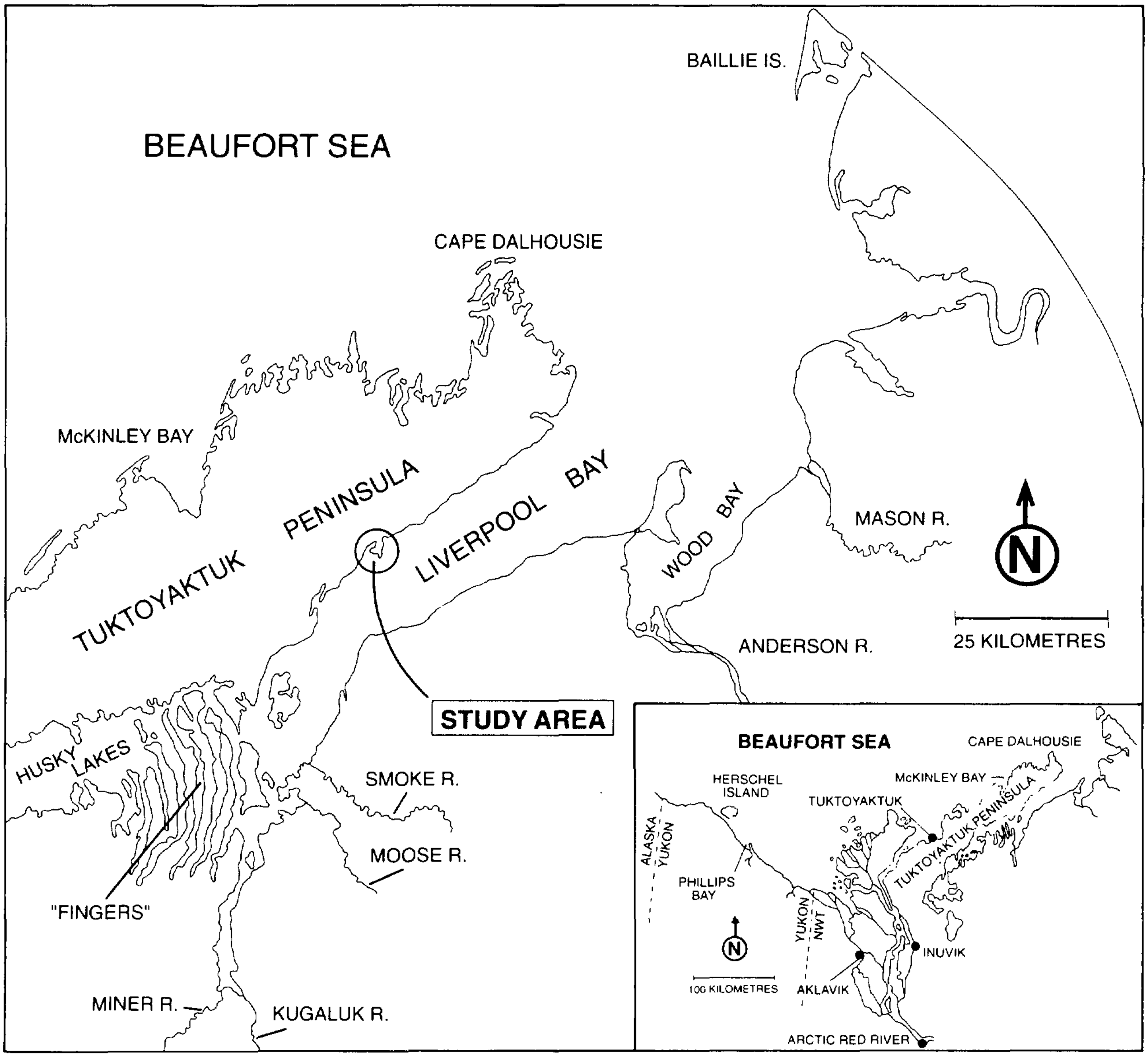

Fig. 1. Liverpool Bay showing the location of the study area.

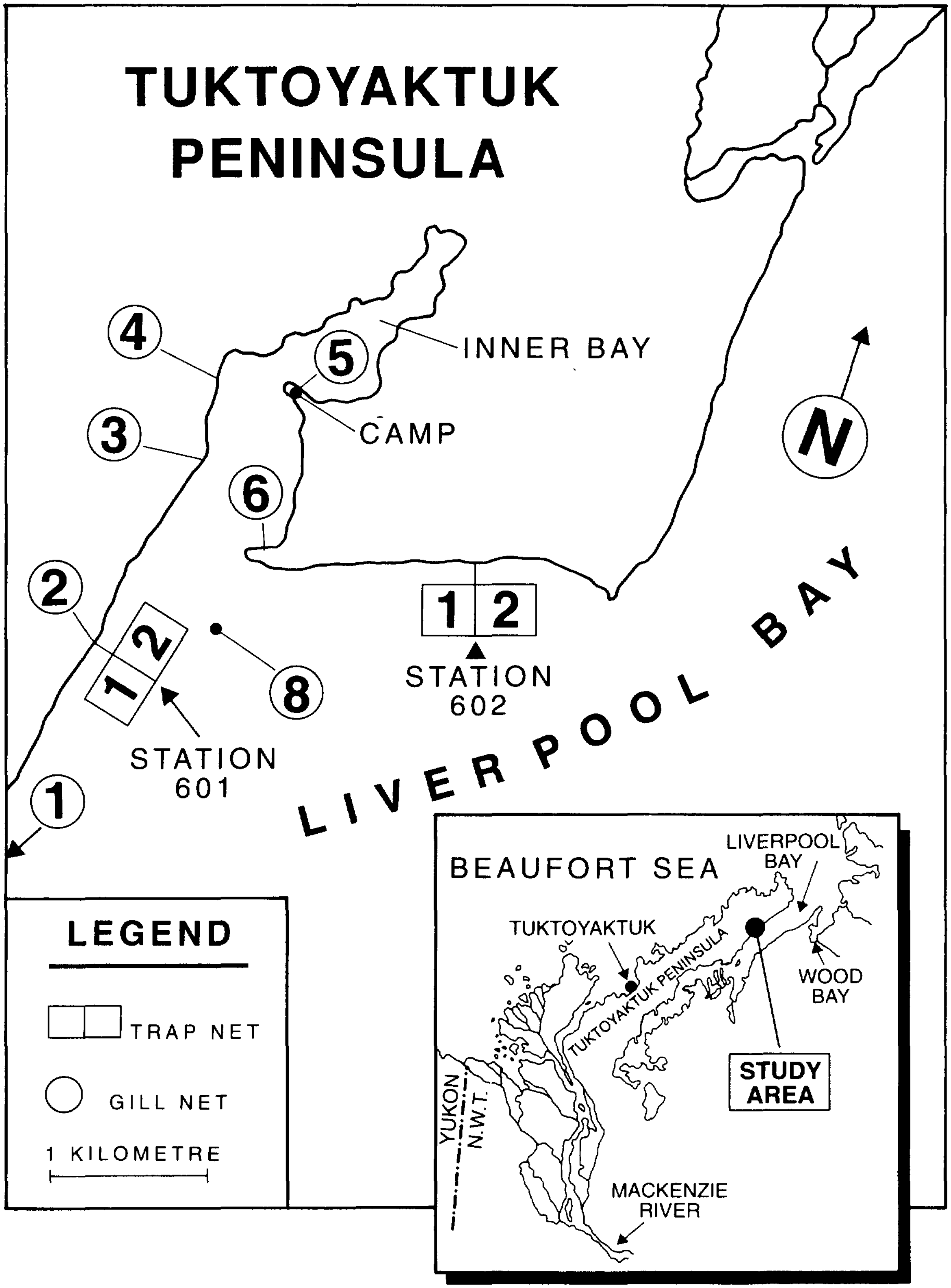

Fig. 2. Liverpool Bay showing location of the trap net stations, 1991.

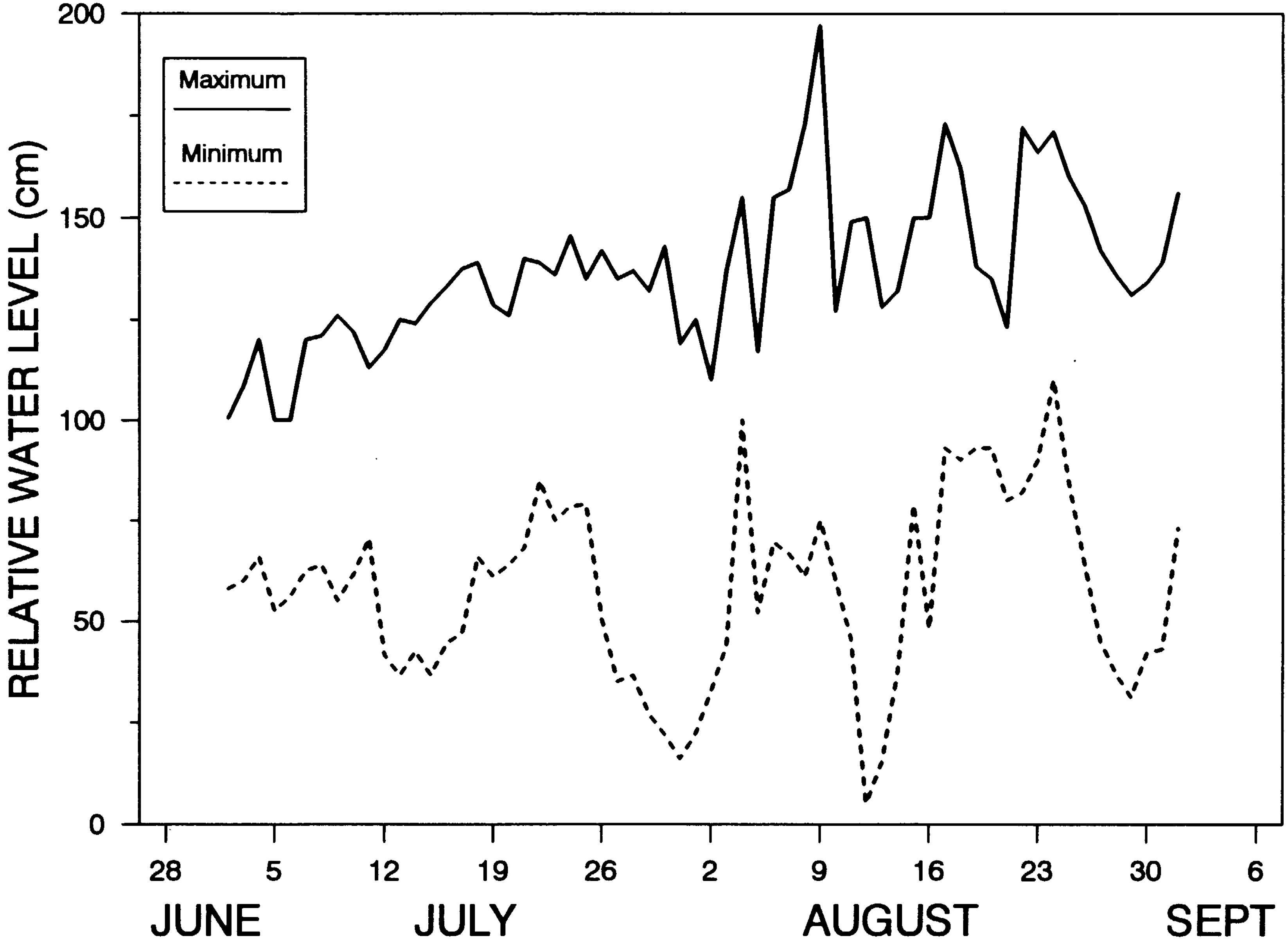

Fig. 3. Water levels recorded at Liverpool Bay during 1991.

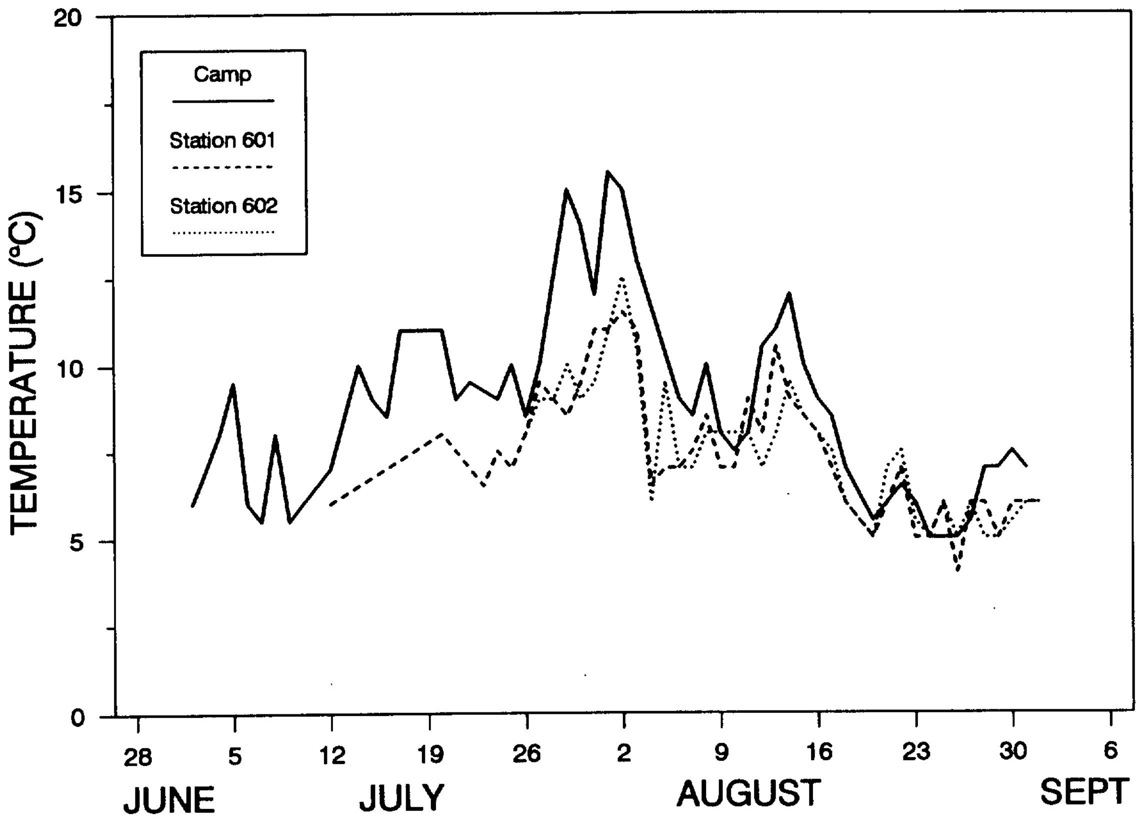

Fig. 4. Daily water temperatures recorded at the trap net stations, Liverpool Bay, 1991.

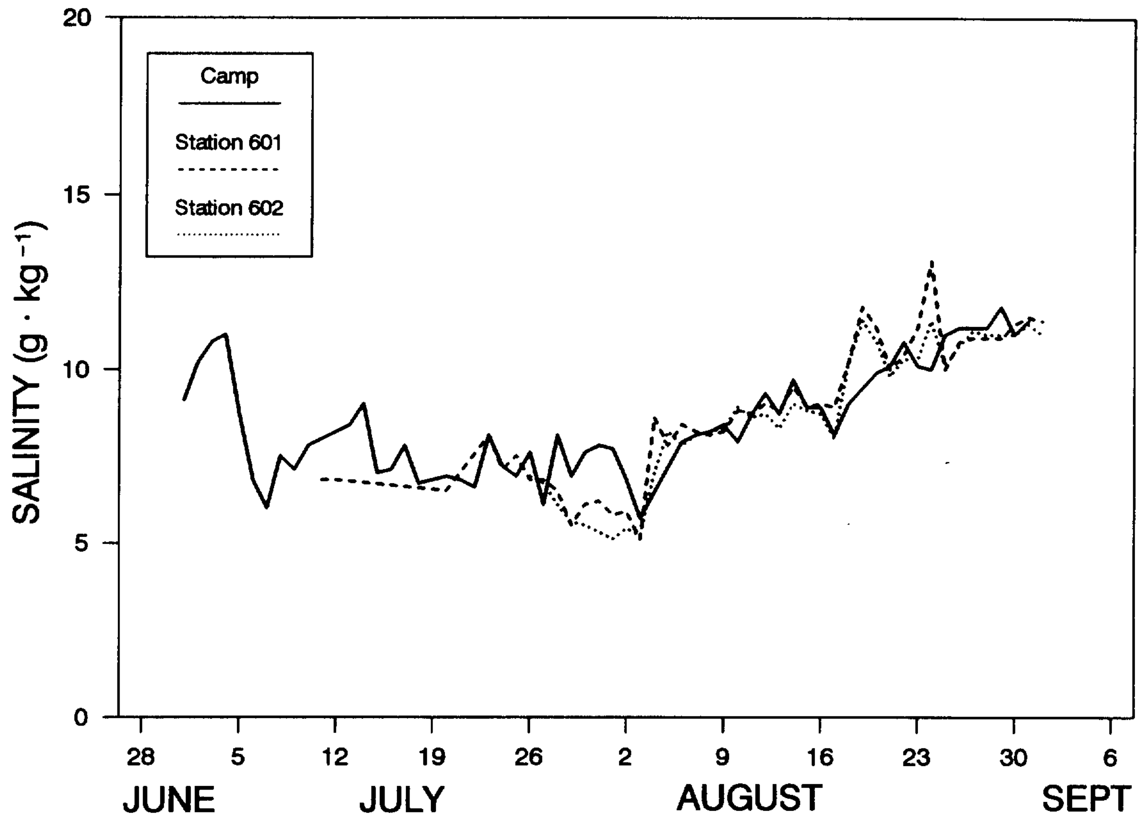

Fig. 5. Daily salinity values recorded at the trap net stations, Liverpool Bay, 1991.

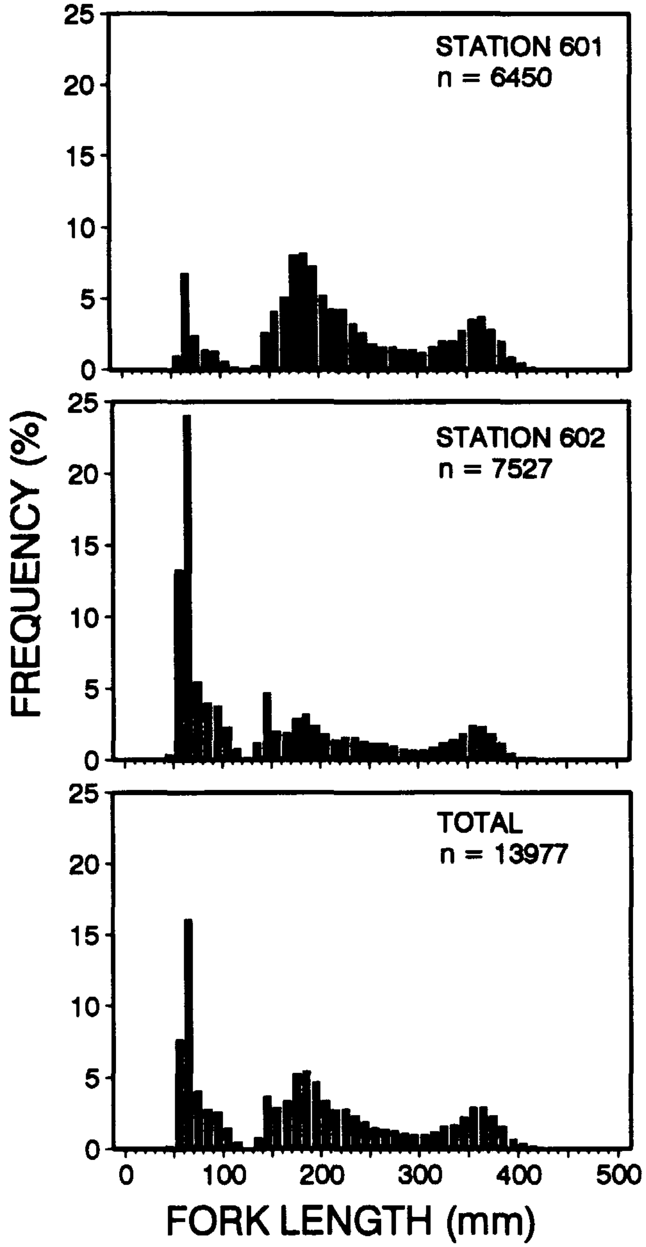

Fig. 6. Length-frequency distribution for Arctic cisco captured in trap nets at Liverpool Bay, 1991.

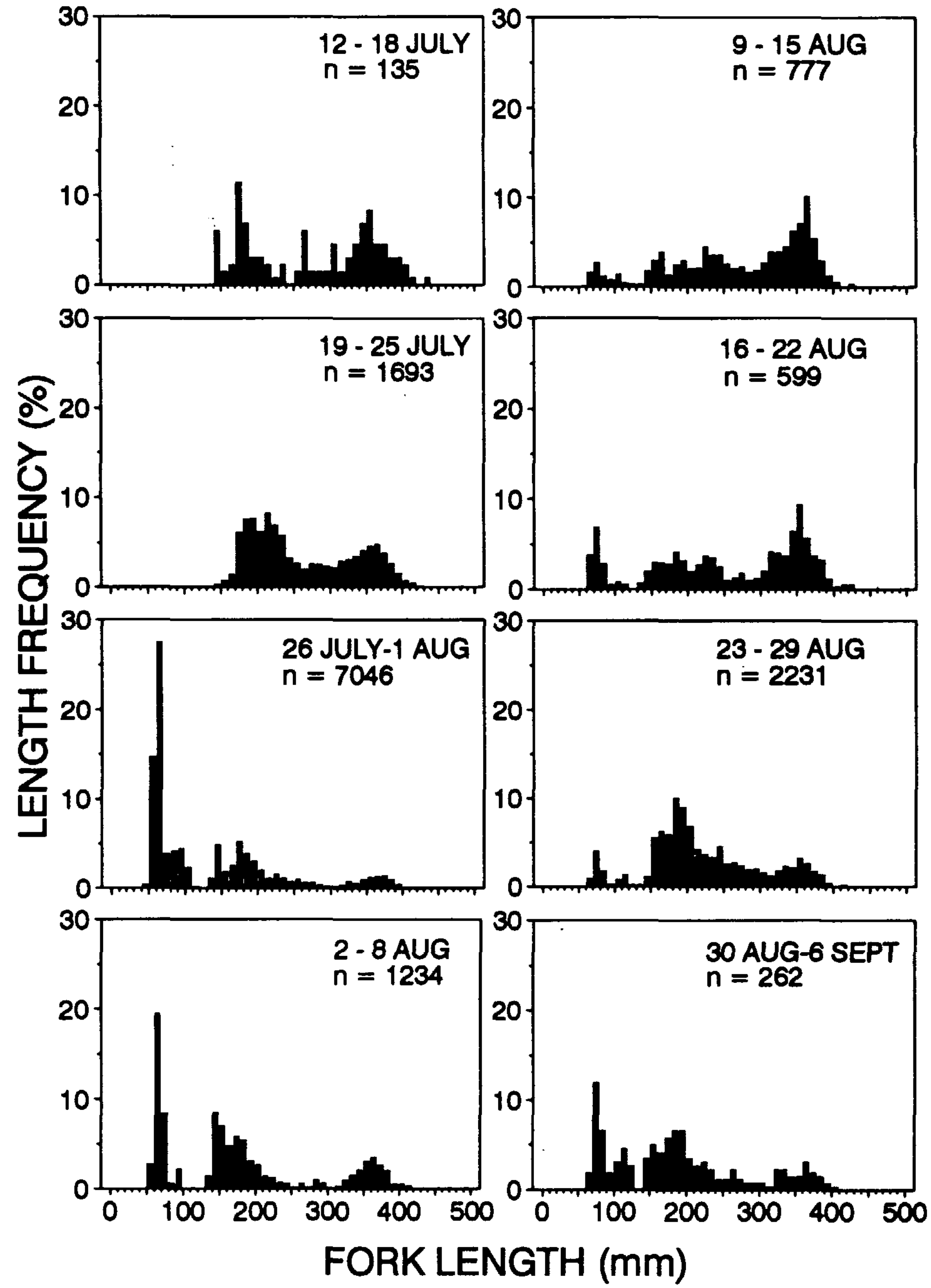

Fig. 7. Seasonal variation in length-frequency distribution of Arctic cisco captured in trap nets at Liverpool Bay, 1991.

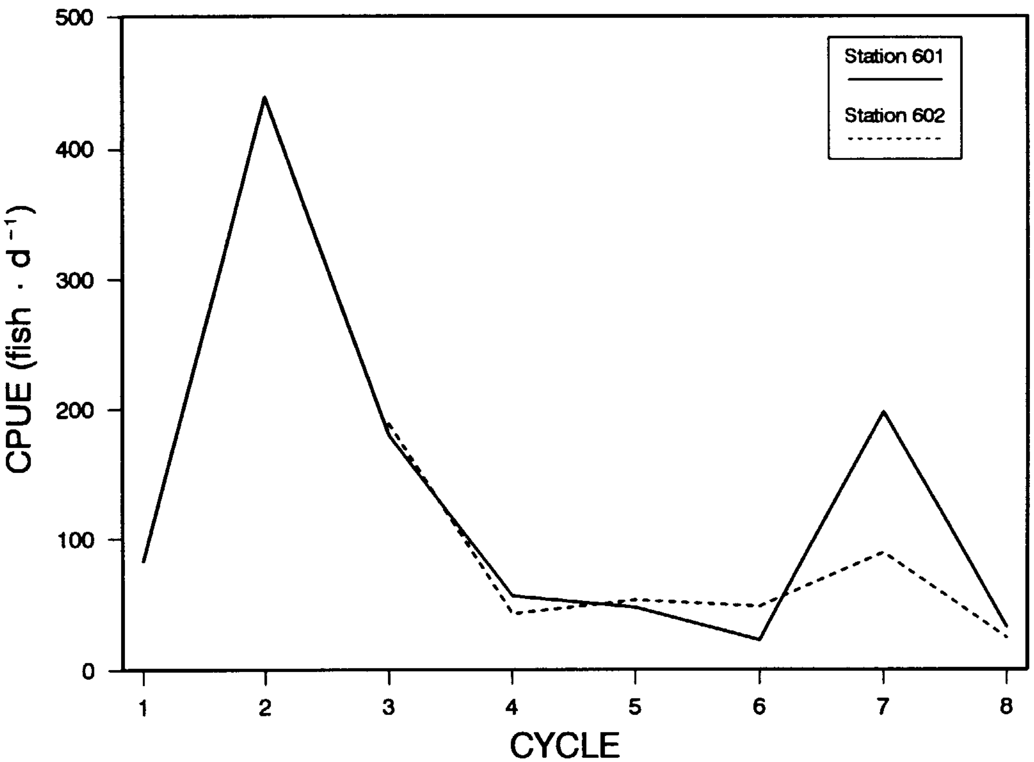

Fig. 8. Seasonal trends in CPUE for large Arctic cisco (≥150 mm) at Liverpool Bay, 1991.

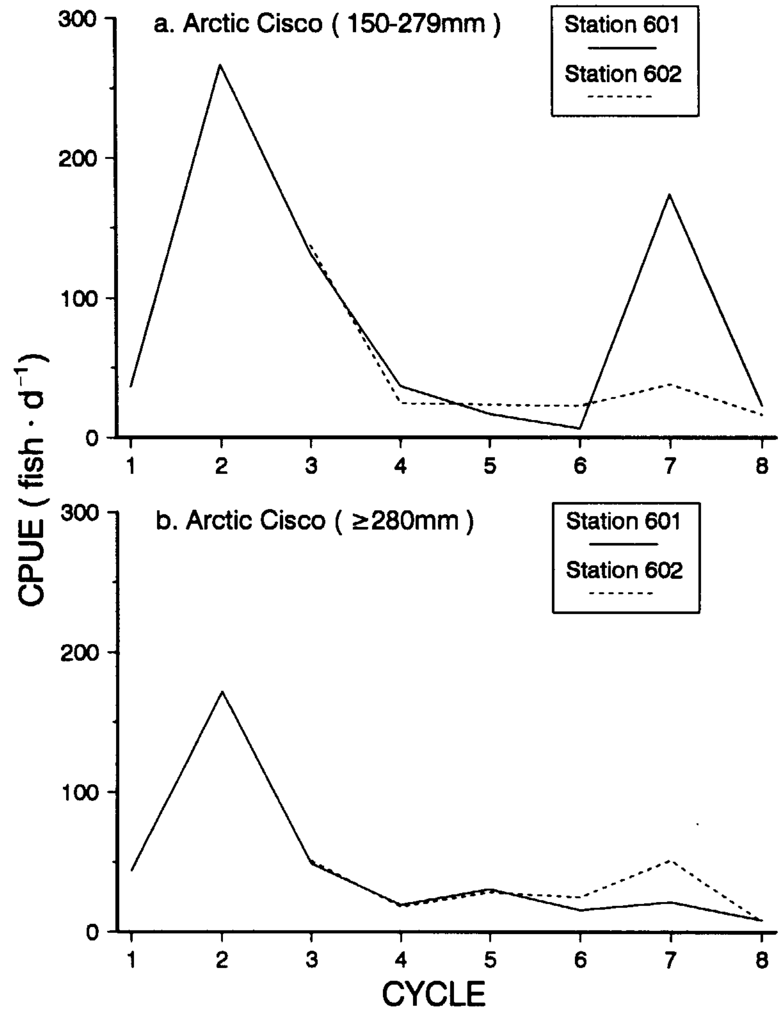

Fig. 9. Seasonal trends in CPUE for two size categories of large Arctic cisco at Liverpool Bay, 1991.

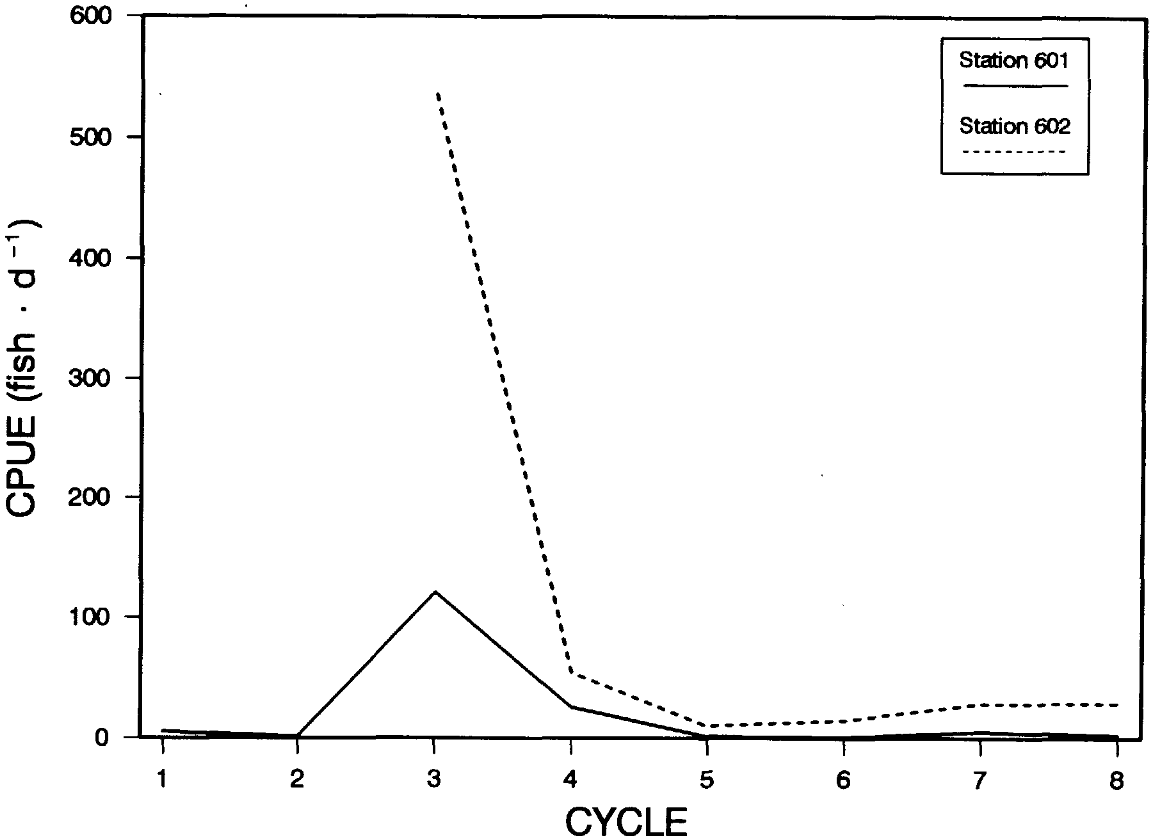

Fig. 10. Seasonal trends in CPUE for small Arctic cisco (<150 mm) at Liverpool Bay, 1991.

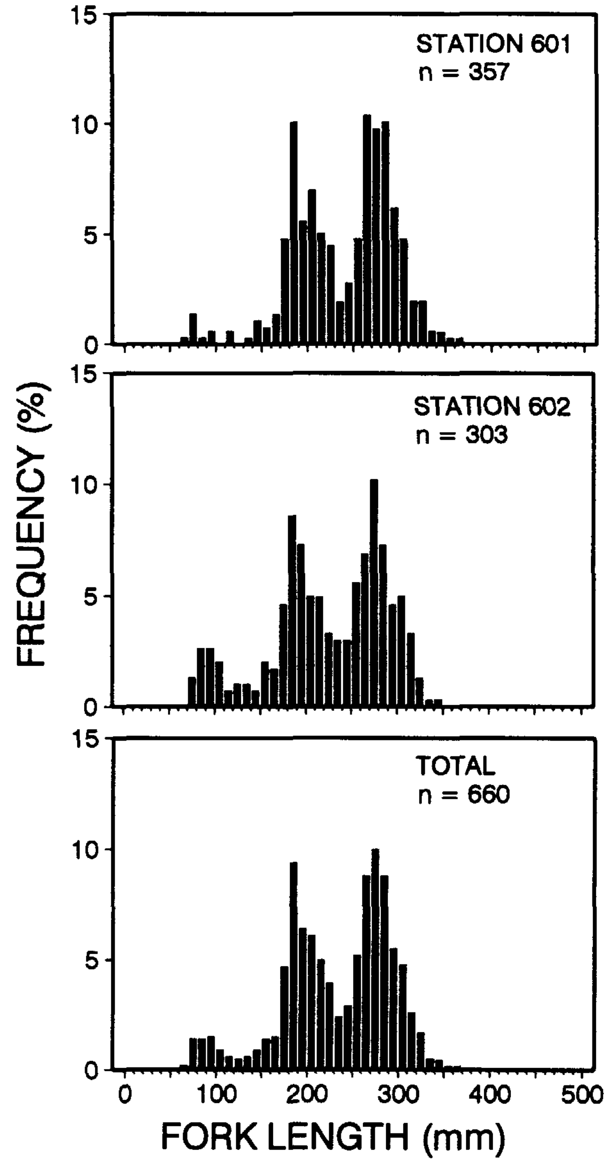

Fig. 11. Length-frequency distribution for least cisco captured in trap nets at Liverpool Bay, 1991.

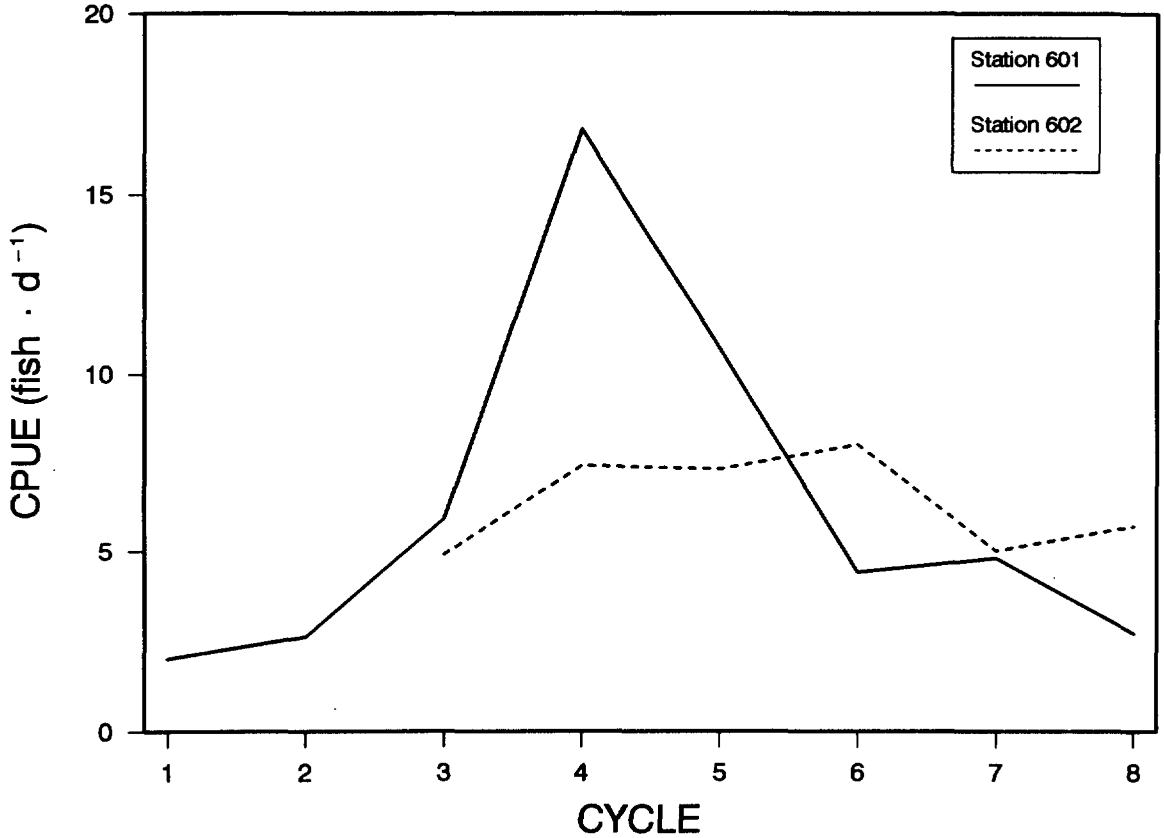

Fig. 12. Seasonal trends in CPUE for large least cisco (≥180 mm) at Liverpool Bay, 1991.

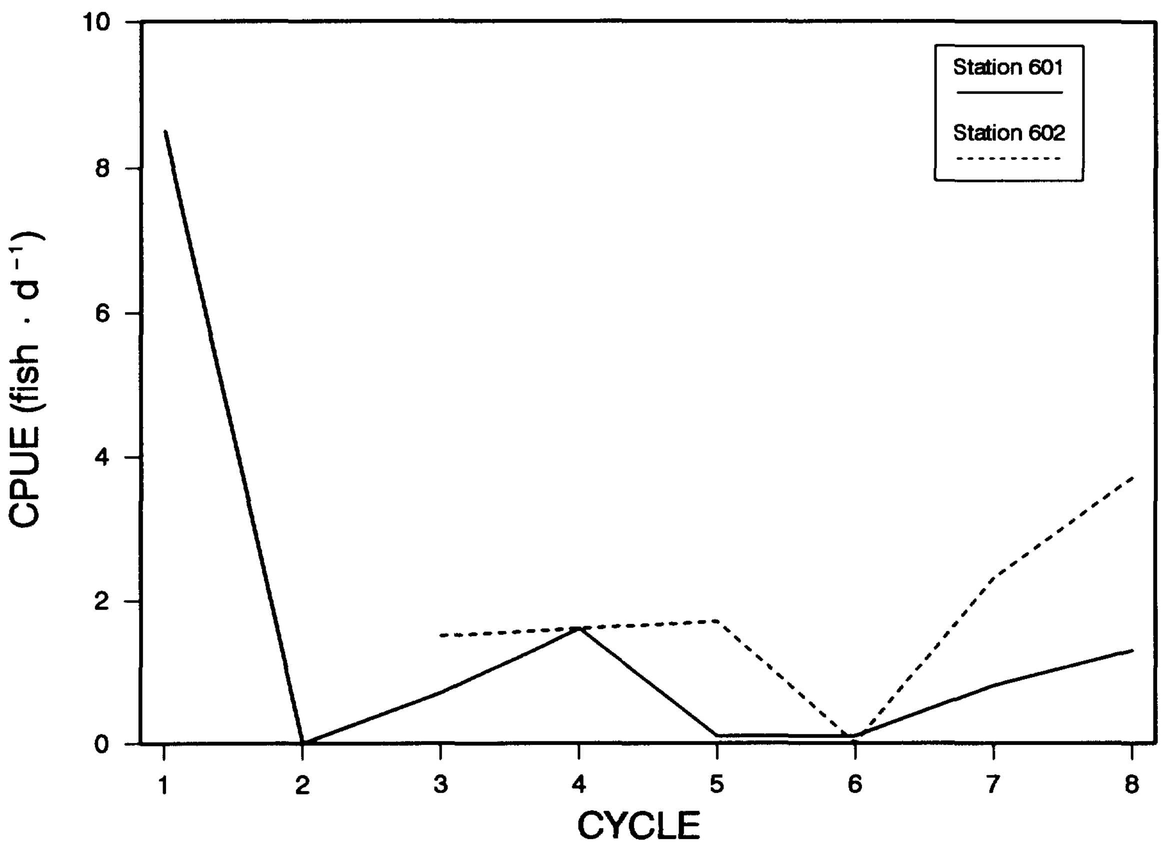

Fig. 13. Seasonal trends in CPUE for small least cisco (<180 mm) at Liverpool Bay, 1991.

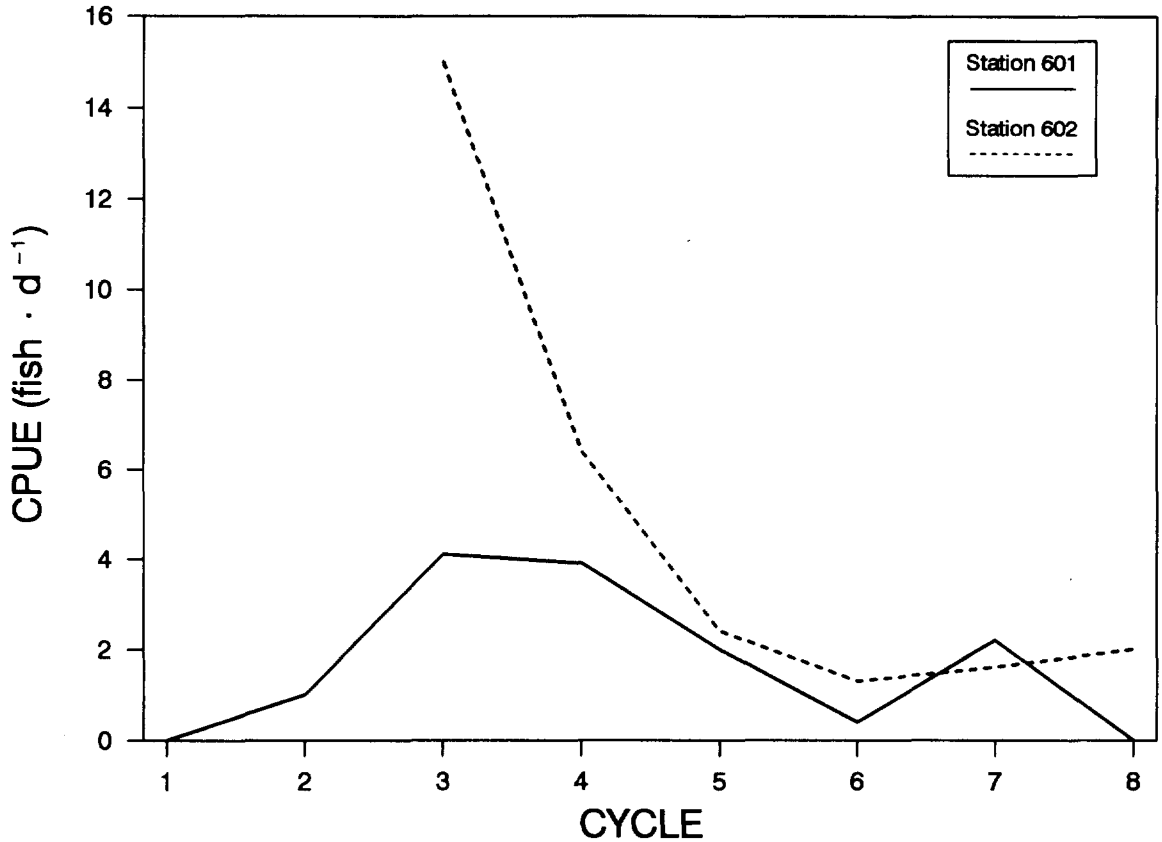

Fig. 14. Seasonal trends in CPUE for broad whitefish at Liverpool Bay, 1991.

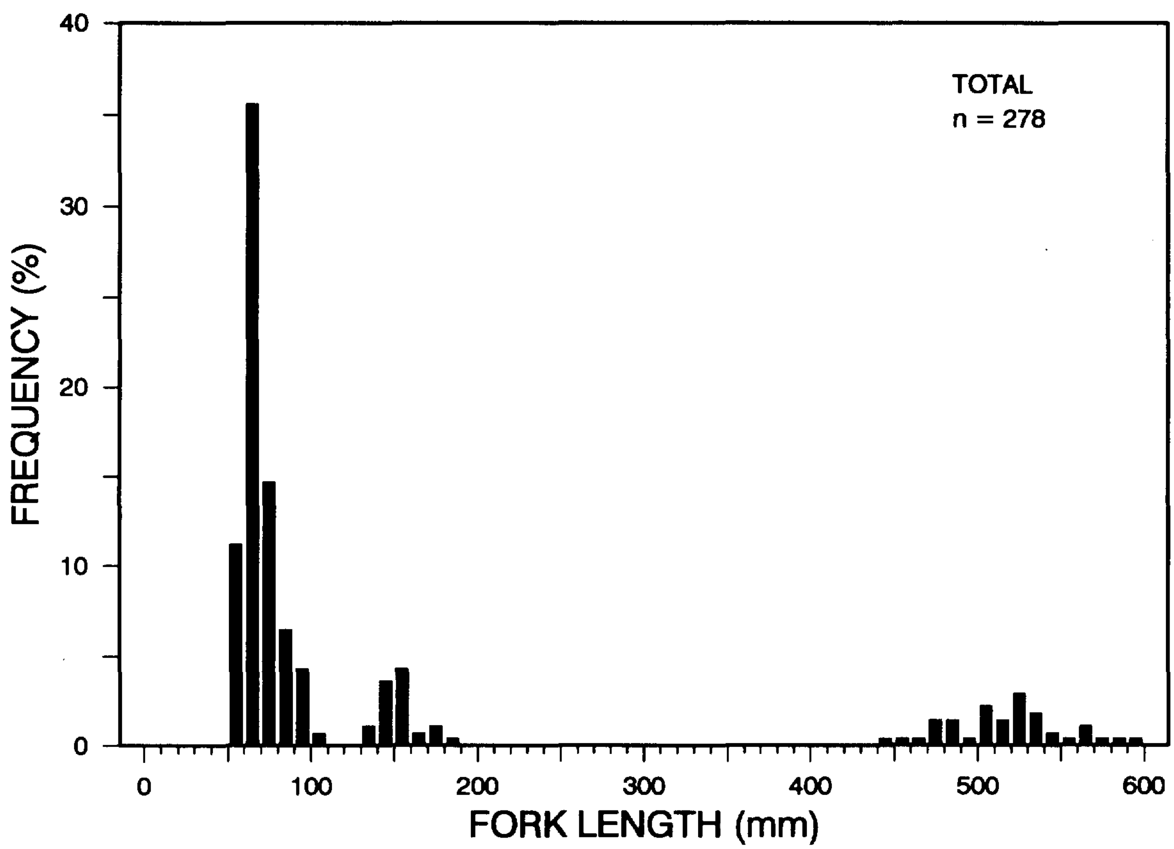

Fig. 15. Length-frequency distribution for broad whitefish captured in trap nets at Liverpool Bay, 1991.

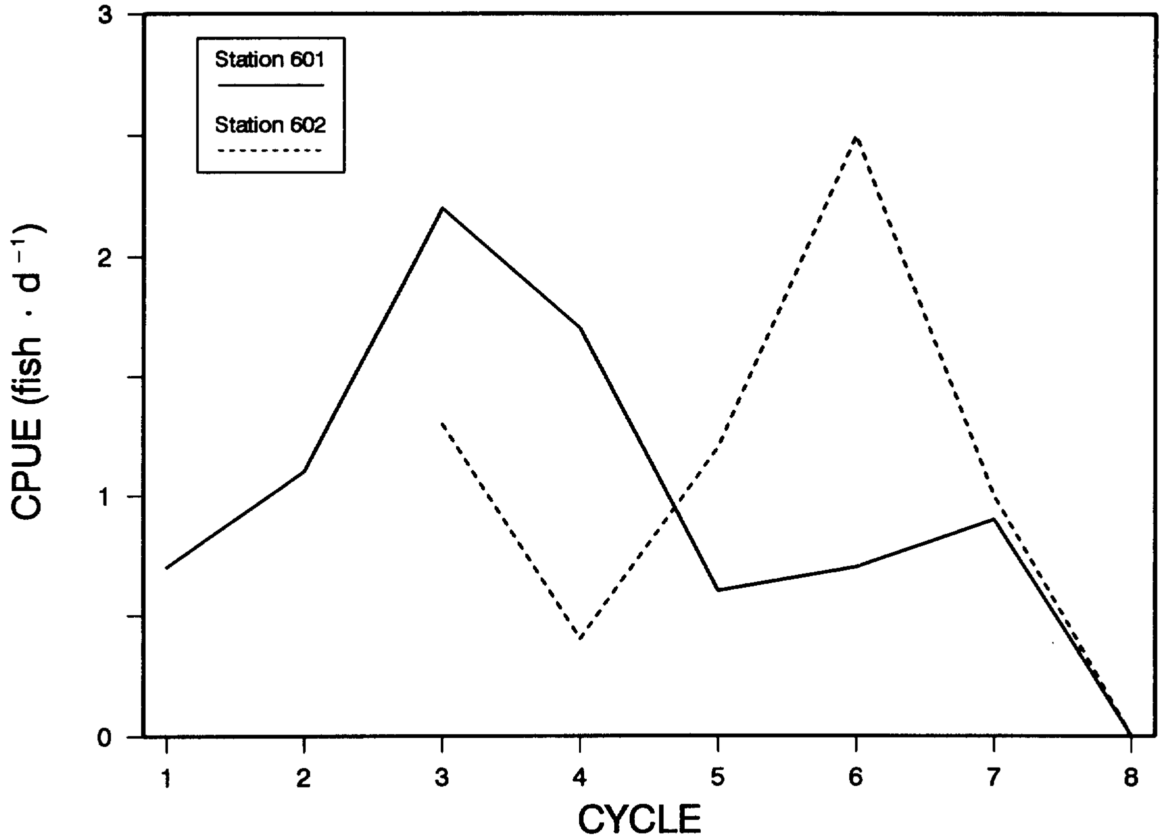

Fig. 16. Seasonal trends in CPUE for lake whitefish at Liverpool Bay, 1991.

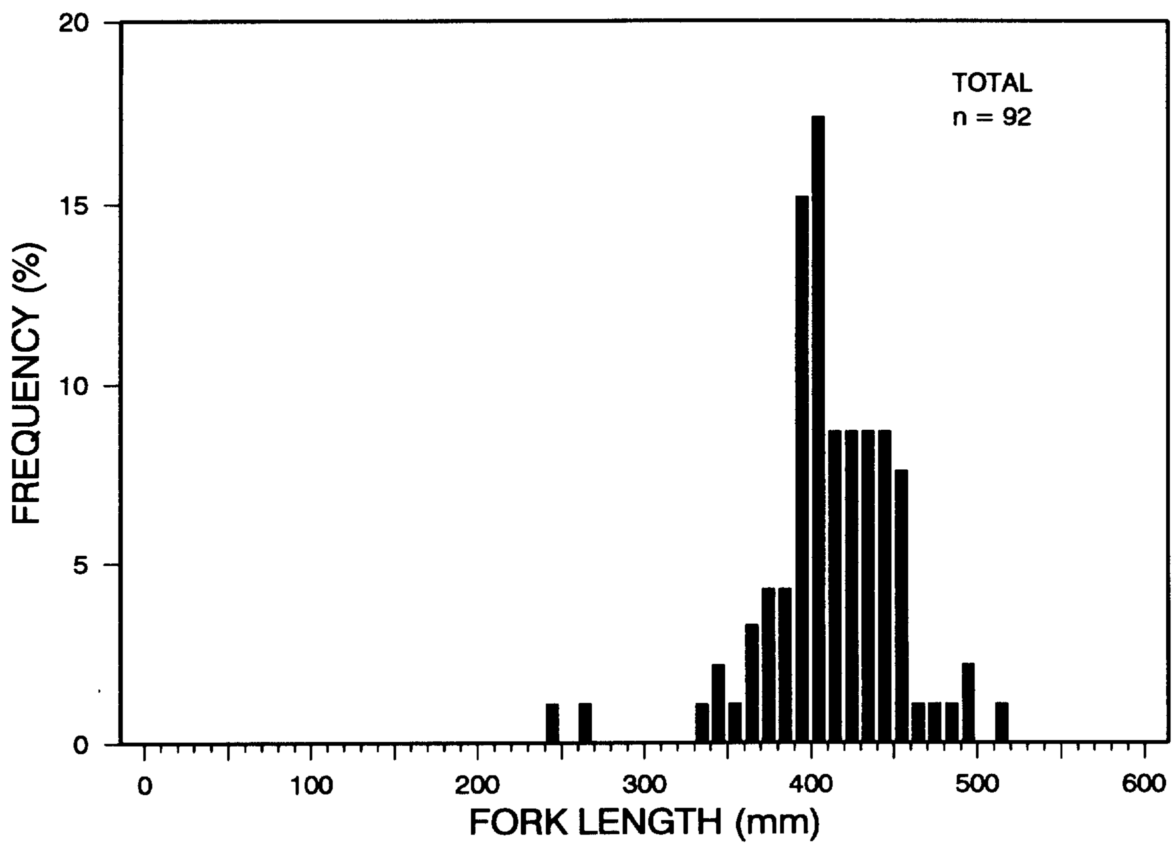

Fig. 17. Length-frequency distribution for lake whitefish captured in trap nets at Liverpool Bay, 1991.

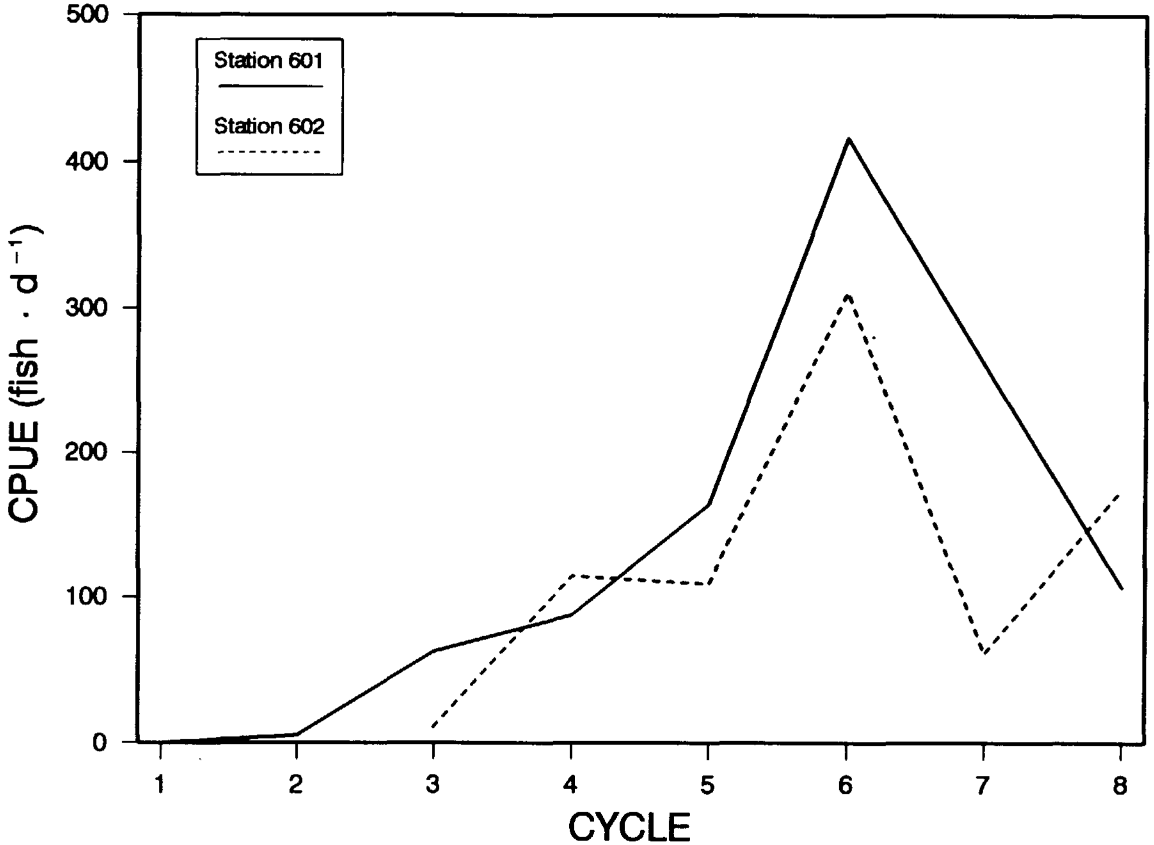

Fig. 18. Seasonal trends in CPUE for saffron cod at Liverpool Bay, 1991.

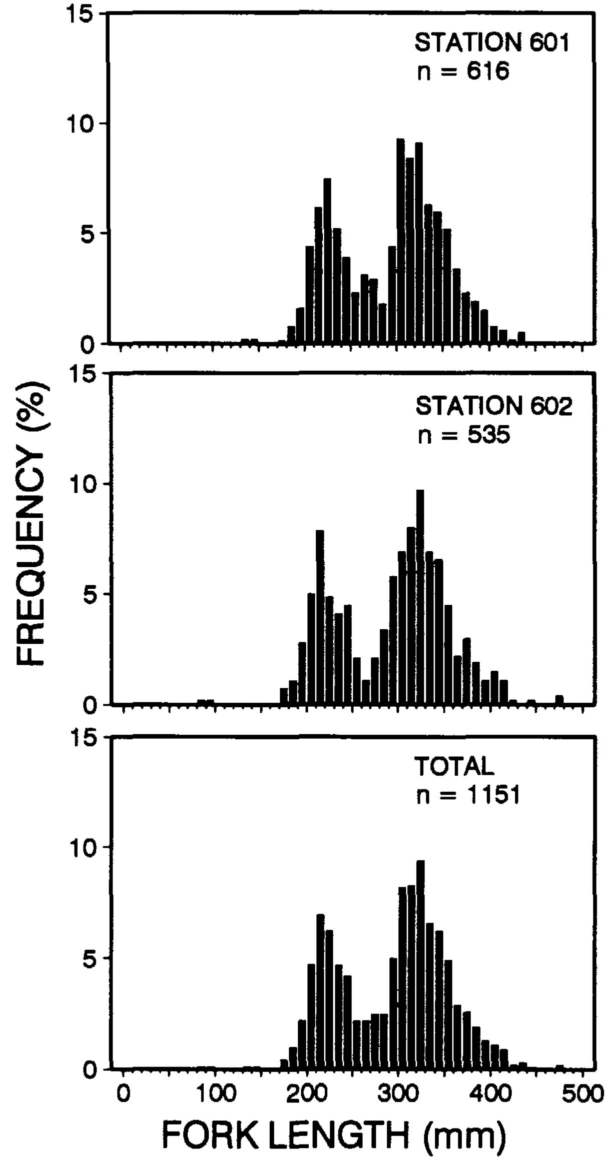

Fig. 19. Length-frequency distribution for saffron cod captured in trap nets at Liverpool Bay, 1991.

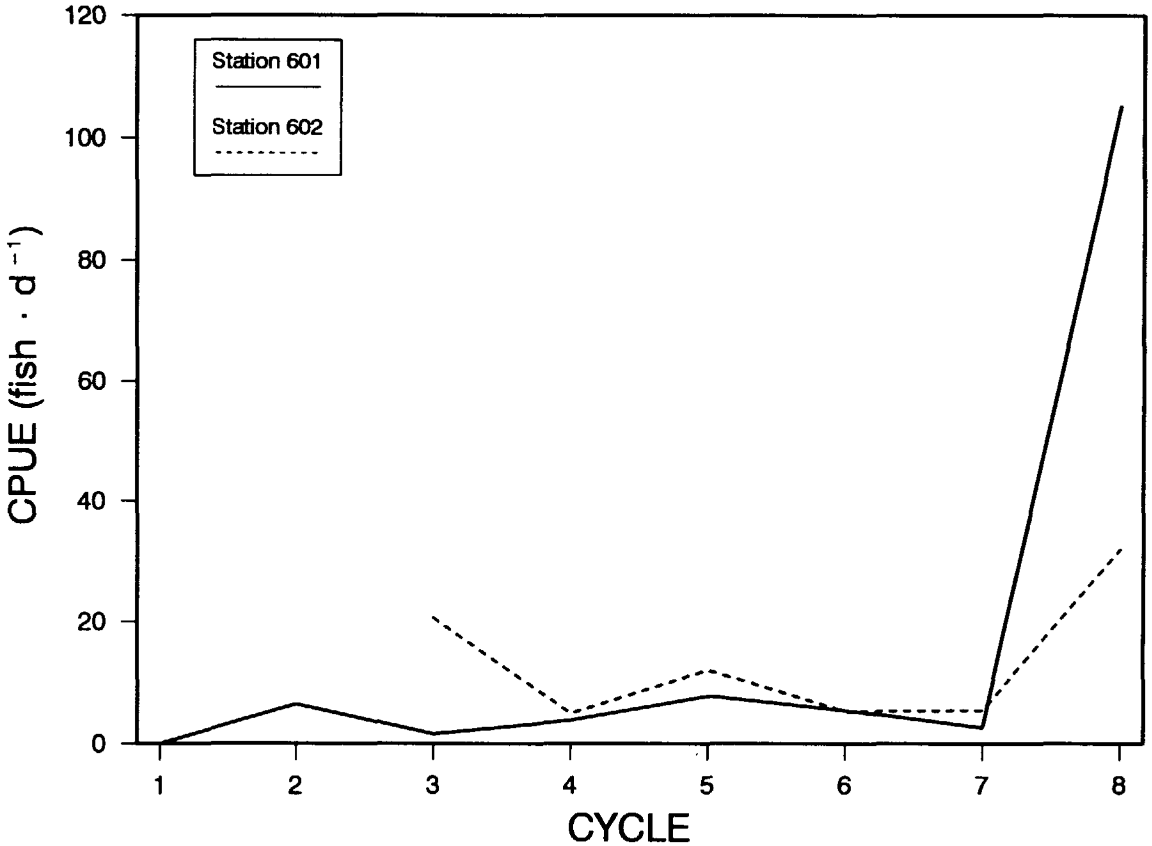

Fig. 20. Seasonal trends in CPUE for Pacific herring at Liverpool Bay, 1991.

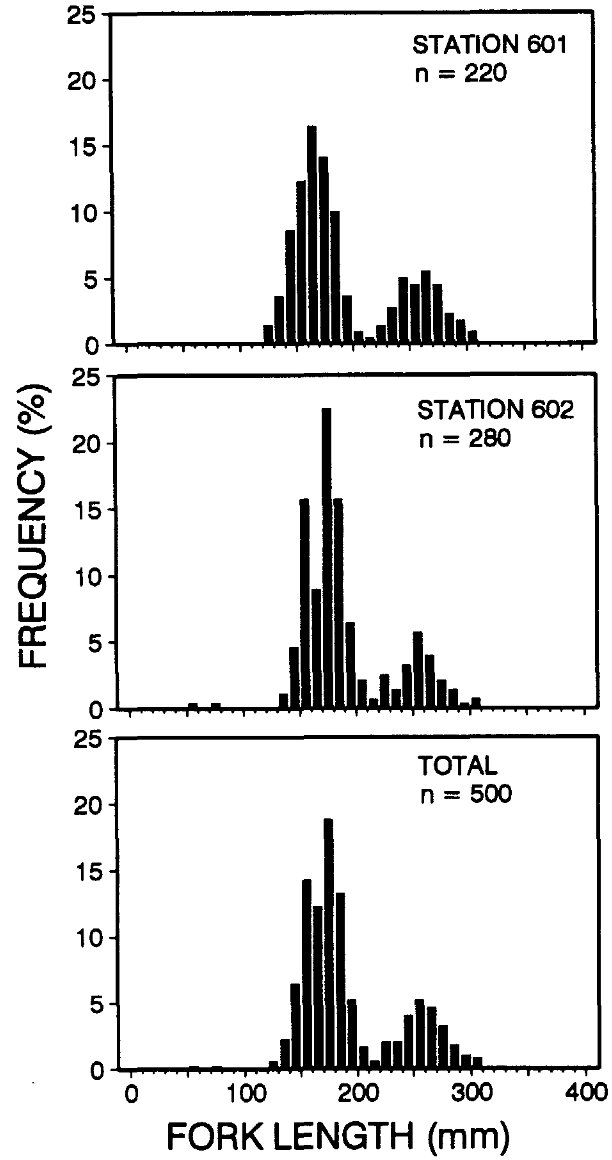

Fig. 21. Length-frequency distribution for Pacific herring captured in trap nets at Liverpool Bay, 1991.

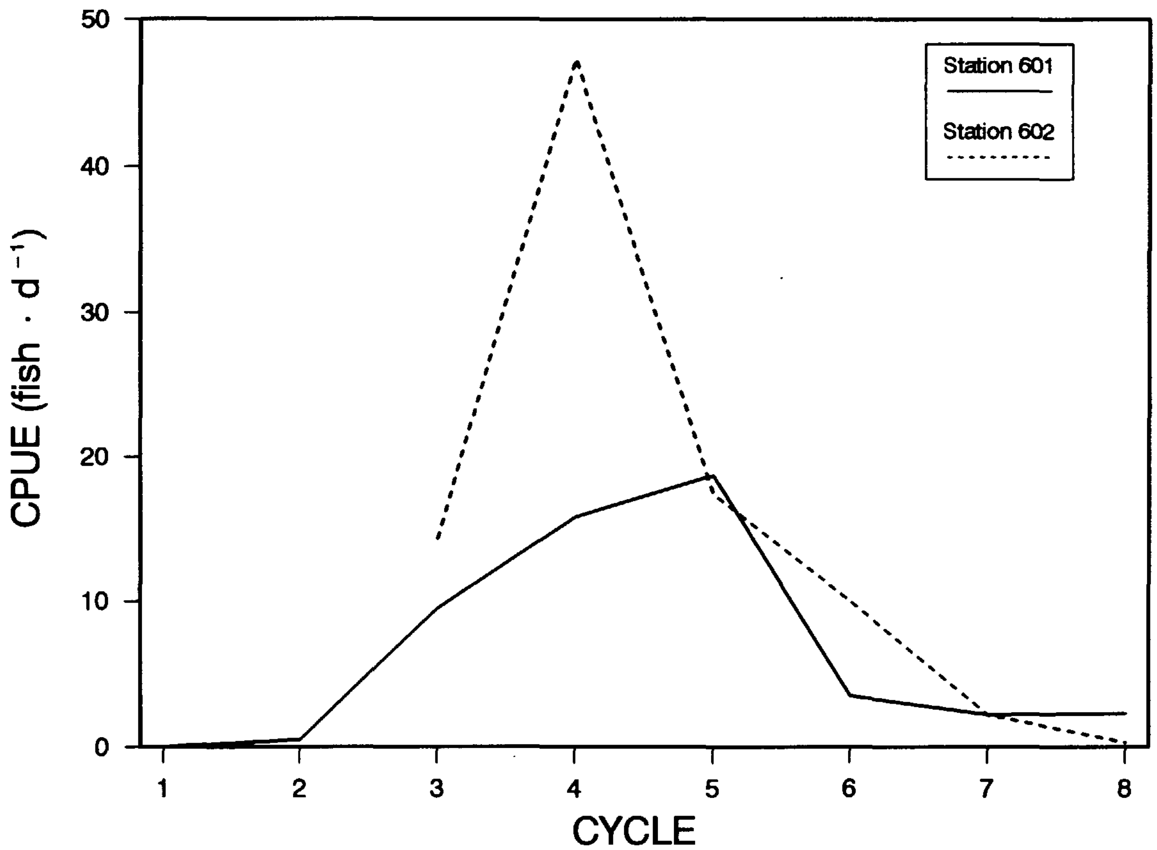

Fig. 22. Seasonal trends in CPUE for rainbow smelt at Liverpool Bay, 1991.

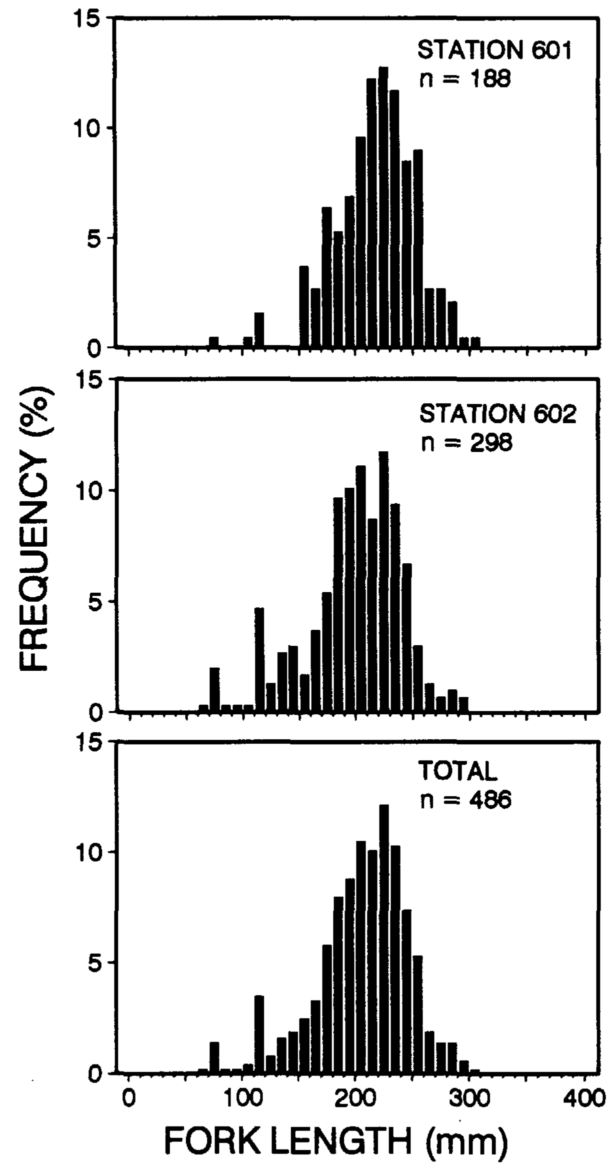

Fig. 23. Length-frequency distribution for rainbow smelt captured in trap nets at Liverpool Bay, 1991.

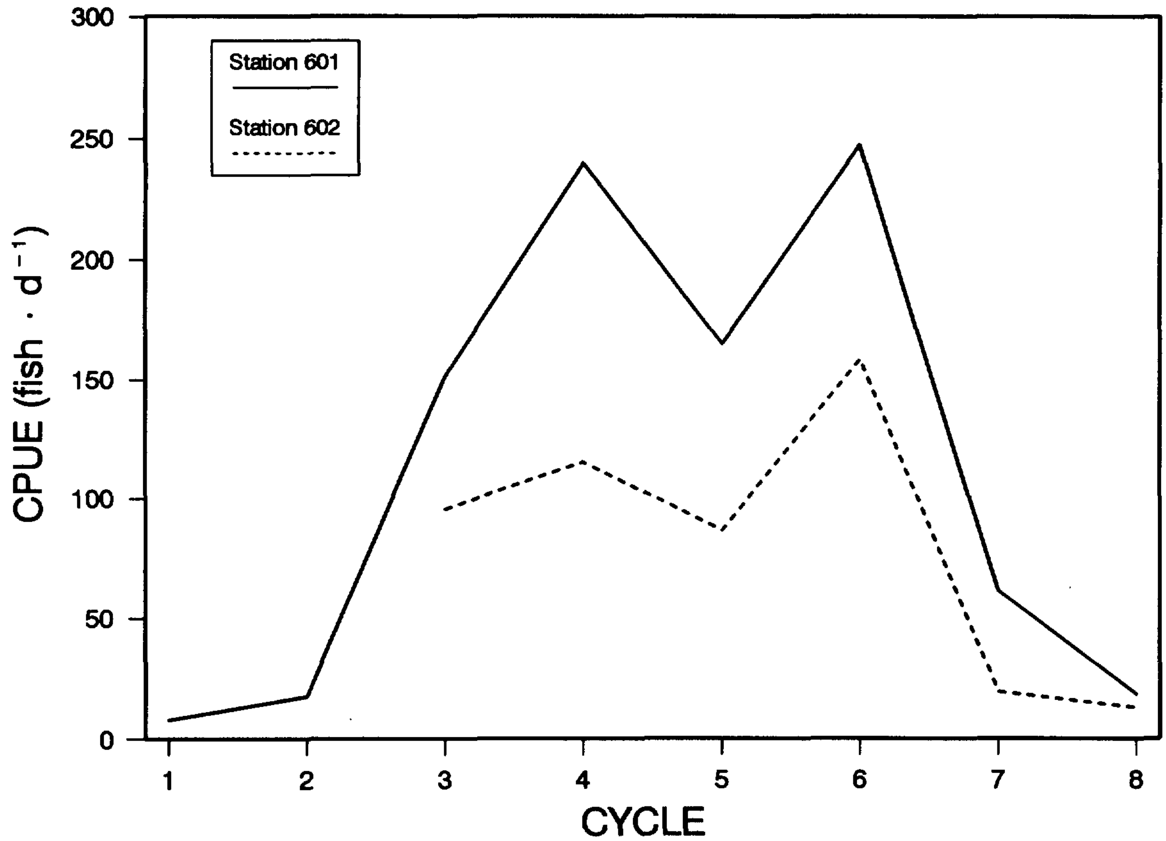

Fig. 24. Seasonal trends in CPUE for Arctic flounder at Liverpool Bay, 1991.

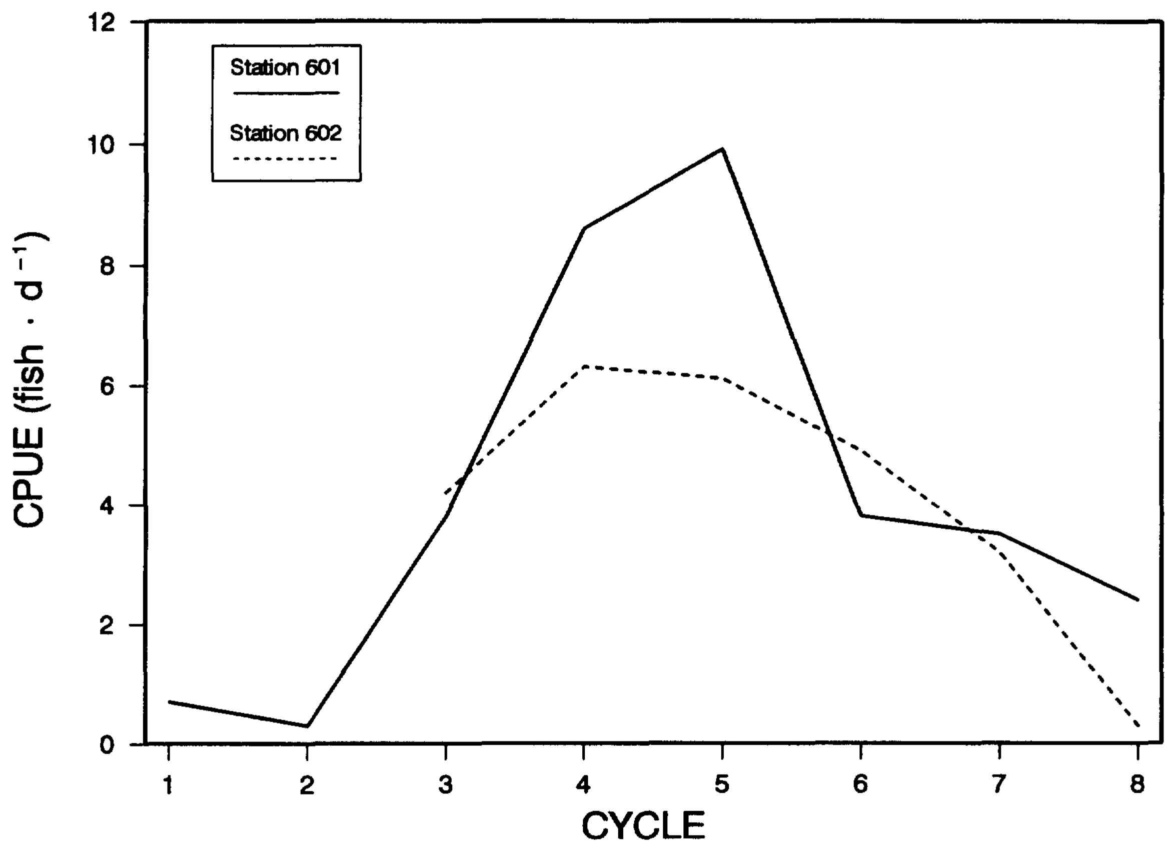

Fig. 25. Seasonal trends in CPUE for fourhorn sculpin at Liverpool Bay, 1991.

Appendix A1. Water temperature, salinity, and catch data from gillnet sets, Liverpool Bay, 1991[1].

Lift Date	Site[2]	Number Captured by Species: ARCS	LSCS	BDWT	LKWT	INCO	SFCD	PCHR	ARFL	FHSC	STFL	RNSM	GLCD	ARSC	ASSC	Total	Time of Lift(h)	Set Dura. (min)	Water Temp (°C)	Sal. (g·kg^{-1})
01 July	700(4)	1														1	1740	140	3.0	9.1
02	700(4)	1					9									10	1610	190	4.0	9.9
03	701(1)									1	1					2	1640	130	2.5	9.4
04	702(2)	17														17	1400	980	ND	10.9
05	702(2)	14							2							16	1340	1385	2.0	7.8
05	703(3)	15			2						1					18	2300	285	ND	ND
06	704(5)								1							1	1515	75	ND	ND
08	703(3)	19					5		1	1						26	0420	860	2.0	5.7
09	703(3)	3			1						1					5	1405	1280	5.5	7.7
10	702(2)	24														24	1330	1380	3.0	6.8
11	702(2)	23							1							24	1100	1260	ND	ND
13	801(8)	1					2			1						4	1445	1125	4.0	7.0
14	703(3)	30				1		8								39	2240	575	2.0	6.8
17	723(6)	43			1		8	2	3	1						58	0800	615	4.0	6.5
18	723(6)	29	1	1			29	26	1	2						89	1015	720	4.5	6.7
24	801(8)	2					2	9								13	1740	1420	6.0	7.8
31 July	801(8)	22					46	27	1	7		4	7	1		115	1945	1325	9.0	5.8
07 Aug.	801(8)	7					46	6	9	2		7		1	1	79	2005	1400	7.0	8.1
14 Aug.	801(8)	1					15		1	6				3		26	1950	1315	8.0	9.2
21 Aug.	801(8)						8	2		3			1	2		16	1550	1045	5.0	11.9
28 Aug.	801(8)	1					3		1	3						8	2020	1415	4.5	10.1
Total		253	1	1	4	1	173	80	21	27	3	11	8	7	1	591		18920		

[1] Temperature and salinity values for Site 801(8) are bottom readings (5m).
[2] Numbers in parentheses refer to Site numbers shown in Figure 2.

Appendix A2.1. Daily catch of small (< 150 mm) Arctic cisco by codend trap, Liverpool Bay, 1991.

	Number by station and side of trap						
	Station 601			Station 602			Grand
Date	01	02	Total	01	02	Total	Total
12 July				ND	ND	ND	0
13	7	1	8	ND	ND	ND	8
20	1		1	ND	ND	ND	1
21	1		1	ND	ND	ND	1
23		1	1	ND	ND	ND	1
24				ND	ND	ND	0
25	1	1	2	ND	ND	ND	2
26	6		6	2	2	4	10
27	3	3	6	5	12	17	23
28	1	32	33	5	423	428	461
29	1	341	342	10	2245	2255	2597
30	1	136	137	12	419	431	568
31	8	172	180	16	215	231	411
01 August	11	105	116	22	323	345	461
02	2	27	29	11	280	291	320
03	6	138	144	11	55	66	210
04		3	3	5	1	6	9
05		1	1	1		1	2
06					1	1	1
07					2	2	2
08					5	5	5
09							0
10							0
11	2		2		5	5	7
12		3	3	2	3	5	8
13		5	5	3	7	10	15
14				5	46	51	51
15				1		1	1
16		5	5	2	87	89	94
17				7		7	7
18		1	1				1
19							0
20							0
21					2	2	2
22				1	3	4	4
23	2		2		1	1	3
24				5	0	5	5
25	2	2	4	1	1	2	6
26	1	1	2	1	1	2	4
27	2	1	3		24	24	27
28	2	8	10	7		7	17
29	5	10	15	6	150	156	171
30		1	1	17	51	68	69
31	1	2	3	1	11	12	15
01 September		4	4		6	6	10
Total	66	1004	1070	159	4381	4540	5610

Appendix A2.2. Daily catch of large (≥ 150 mm) Arctic cisco by codend trap, Liverpool Bay, 1991.

	Number by station and side of trap						
	Station 601			Station 602			Grand
Date	01	02	Total	01	02	Total	Total
12 July	7	2	9			ND	9
13	39	79	118			ND	118
20	210	98	308			ND	308
21	136	55	191			ND	191
23	166	335	501			ND	501
24	111	75	186			ND	186
25	358	144	502			ND	502
26	188	42	230	312	15	327	557
27	137	115	252	302	50	352	604
28	139	91	230	161	21	182	412
29	71	116	187	160	11	171	358
30	70	46	116	67	5	72	188
31	48	44	92	40	8	48	140
01 August	50	58	108	134	14	148	256
02	49	119	168	103	5	108	276
03	65	27	92	56	0	56	148
04	4	31	35	11	2	13	48
05	12	9	21	19	18	37	58
06	10	11	21	15	9	24	45
07	9	18	27	19	9	28	55
08	19	8	27	13	15	28	55
09	1	1	2	59	3	62	64
10	29	39	68	42	7	49	117
11	29	9	38	22	7	29	67
12	39	35	74	26	11	37	111
13	31	57	88	40	15	55	143
14	8	21	29	46	10	56	85
15	27	3	30	72	6	78	108
16	14	13	27	102	1	103	130
17	23	8	31	20	2	22	53
18	71	2	73	30		30	103
19	6	2	8	11	4	15	23
20	2		2	22	3	25	27
21	1	3	4	28	4	32	36
22	6	4	10	93	16	109	119
23	27	11	38	54	6	60	98
24	9	9	18	50	19	69	87
25	4	12	16	105		105	121
26	78	82	160	41	3	44	204
27	11	34	45	121	30	151	196
28	59	888	947	119	10	129	1076
29	6	148	154	53	9	62	216
30	5	14	19	18	9	27	46
31		43	43	8	8	16	59
01 September	19	16	35	10	18	28	63
Total	2403	2977	5380	2604	383	2987	8367

Appendix A2.3. Daily catch of small (<180 mm) least cisco by codend trap, Liverpool Bay, 1991.

Date	Number by station and side of trap: Station 601 01	Station 601 02	Station 601 Total	Station 602 01	Station 602 02	Station 602 Total	Grand Total
12 July	1	1	2			ND	2
13	6	5	11			ND	11
20						ND	0
21						ND	0
23						ND	0
24						ND	0
25						ND	0
26							0
27	1		1				1
28	1		1		1	1	2
29		1	1		1	1	2
30					4	4	4
31	1		1				1
01 August		1	1	2	2	4	5
02	2		2	1	5	6	8
03	1	1	2	1		1	3
04	1	3	4				4
05	0	1	1	1		1	2
06	1		1				1
07		1	1		2	2	3
08					1	1	1
09							0
10							0
11					2	2	2
12							0
13		1	1		3	3	4
14					5	5	5
15				1	1	2	2
16	1		1				1
17							0
18							0
19							0
20							0
21							0
22							0
23							0
24				1		1	1
25		2	2	1	1	2	4
26				2		2	2
27		2	2	1	3	4	6
28	1		1	2	2	4	5
29		1	1	2	1	3	4
30		1	1	1	5	6	7
31		3	3	2	2	4	7
01 September				1		1	1
Total	17	24	41	19	41	60	101

Appendix A2.4. Daily catch of large (≥180 mm) least cisco by codend trap, Liverpool Bay, 1991.

Date	Number by station and side of trap: Station 601 01	Station 601 02	Station 601 Total	Station 602 01	Station 602 02	Station 602 Total	Grand Total
12 July						ND	0
13		3	3			ND	3
20	1		1			ND	1
21	1	1	2			ND	2
23	2		2			ND	2
24	2		2			ND	2
25	3		3			ND	3
26							0
27	7	2	9	2	1	3	12
28	5	2	7	3		3	10
29	2		2	1	2	3	5
30	8	2	10	1		1	11
31	7		7	7		7	14
01 August	4	1	5	13	4	17	22
02	13	9	22	10	5	15	37
03	23	7	30	8	2	10	40
04	3	9	12	3	1	4	16
05	6	2	8	3	2	5	13
06	3	2	5	3	1	4	9
07	11	6	17	3	1	4	21
08	20	3	23	3	7	10	33
09	4	4	8	4		4	12
10	1	2	3	5	2	7	10
11	3	1	4	4	2	6	10
12	13	5	18	11	3	14	32
13	15	5	20	5	6	11	31
14	12	3	15	3	2	5	20
15	4	2	6	4		4	10
16	12	3	15	13		13	28
17	1	1	2	13	2	15	17
18	2	1	3	4		4	7
19	3		3	6		6	9
20	1		1	5		5	6
21	1	3	4	6	1	7	11
22	2	1	3	6		6	9
23	6		6	7	2	9	15
24	4		4	4	1	5	9
25	5	5	10	2		2	12
26	3		3	2		2	5
27		3	3	5	3	8	11
28	2	3	5	3	4	7	12
29		3	3	2		2	5
30		3	3	2		2	5
31	1	3	4	1	3	4	8
01 September	1		1	1	10	11	12
Total	217	100	317	178	67	245	562

Appendix A2.5. Daily catch of broad whitefish by codend trap, Liverpool Bay, 1991.

	Number by station and side of trap						
	Station 601			Station 602			Grand
Date	01	02	Total	01	02	Total	Total
12 July						ND	0
13						ND	0
20	1		1			ND	1
21		1	1			ND	1
23	1		1			ND	1
24						ND	0
25		1	1			ND	1
26		1	1				1
27							0
28							0
29	2		2		50	50	52
30	1	9	10		20	20	30
31	3	8	11		18	18	29
01 August	1	3	4	1	15	16	20
02		7	7		30	30	37
03	1	4	5	1	9	10	15
04	4		4				4
05							0
06	4		4				4
07	4		4	3		3	7
08	2	1	3		1	1	4
09	1		1				1
10	1	1	2	1		1	3
11	2	1	3				3
12		2	2		2	2	4
13		4	4	1	2	3	7
14	1	1	2		8	8	10
15					3	3	3
16		1	1		3	3	4
17					2	2	2
18				1		1	1
19							0
20				1		1	1
21		1	1				1
22		1	1		2	2	3
23		1	1				1
24							0
25		4	4				4
26	1	1	2		1	1	3
27					7	7	7
28		3	3				3
29	1	4	5		3	3	8
30				1	3	4	4
31					1	1	1
01 September					1	1	1
Total	31	60	91	10	181	191	282

Appendix A2.6. Daily catch of lake whitefish by codend trap, Liverpool Bay, 1991.

	Number by station and side of trap						
	Station 601			Station 602			Grand
Date	01	02	Total	01	02	Total	Total
12 July						ND	0
13	1		1			ND	1
20		1	1			ND	1
21						ND	0
23						ND	0
24		2	2			ND	2
25	1		1			ND	1
26							0
27		1	1		2	2	3
28		4	4	1	3	4	8
29		1	1		1	1	2
30	1	4	5				5
31		2	2				2
01 August	1	1	2		2	2	4
02	3	3	6		1	1	7
03							0
04		1	1		1	1	2
05							0
06		2	2				2
07		3	3				3
08					1	1	1
09					2	2	2
10		1	1				1
11				1	1	2	2
12		2	2		3	3	5
13		1	1				1
14					1	1	1
15					1	1	1
16		2	2				2
17							0
18		1	1				1
19				1	1	2	2
20		1	1	1		1	2
21				1	3	4	4
22		1	1		11	11	12
23		2	2		2	2	4
24		1	1	1	1	2	3
25				1		1	1
26					1	1	1
27		1	1				1
28		1	1	1		1	2
29		1	1				1
30							0
31							0
01 September							0
Total	7	40	47	8	38	46	93

Appendix A2.7. Daily catch of Arctic flounder by codend trap, Liverpool Bay, 1991.

	Number by station and side of trap						
	Station 601			Station 602			Grand
Date	01	02	Total	01	02	Total	Total
12 July	2	2	4			ND	4
13	8		8			ND	8
20	8	6	14			ND	14
21	6	3	9			ND	9
23	9	9	18			ND	18
24	1	13	14			ND	14
25	5	7	12			ND	12
26	2	19	21	3	9	12	33
27	25	85	110	22	35	57	167
28	30	134	164	78	98	176	340
29	36	67	103	87	18	105	208
30	30	83	113	47	15	62	175
31	35	184	219	78	53	131	350
01 August	80	215	295	74	41	115	410
02	84	151	235	74	42	116	351
03	80	15	95	114	13	127	222
04	66	256	322	166	64	230	552
05	24	242	266	80	26	106	372
06	110	241	351	33	35	68	419
07	45	146	191	18	26	44	235
08	38	175	213	32	75	107	320
09	13	86	99	16	32	48	147
10	44	150	194	29	23	52	246
11	194	67	261	25	43	68	329
12	18	118	136	24	16	40	176
13	8	134	142	95	26	121	263
14	52	79	131	119	20	139	270
15	124	54	178	127	5	132	310
16	50	20	70	106	7	113	183
17	69	192	261	96	112	208	469
18	27	666	693	49	321	370	1063
19	32	299	331	62	143	205	536
20	16	153	169	44	65	109	278
21	7	116	123	33	38	71	194
22	11	74	85	8	25	33	118
23	6	49	55	18	13	31	86
24	3	97	100	17	19	36	136
25	1	107	108	15	9	24	132
26	11	68	79	5	7	12	91
27	3	28	31	9	2	11	42
28		1	1	11	2	13	14
29	4	48	52	2	5	7	59
30	1	24	25	14	8	22	47
31	1	18	19	7	1	8	27
01 September	4	8	12	4	4	8	20
Total	1423	4709	6132	1841	1496	3337	9469

Appendix A2.8. Daily catch of saffron cod by codend trap, Liverpool Bay, 1991.

	Number by station and side of trap						
	Station 601			Station 602			Grand
Date	01	02	Total	01	02	Total	Total
12 July						ND	0
13						ND	0
20	6		6			ND	6
21	2		2			ND	2
23	3		3			ND	3
24	3	1	4			ND	4
25	4		4			ND	4
26	1		1				1
27	130	8	138	16	1	17	155
28	151	9	160	46	2	48	208
29	80		80	3		3	83
30	33	1	34				34
31	6		6	5	1	6	12
01 August	1	1	2	1		1	3
02							0
03		1	1	1	1	2	3
04	107	90	197	100	13	113	310
05	104	63	167	230	76	306	473
06	99	31	130	222	19	241	371
07	28	6	34	88	25	113	147
08	40	40	80	9	13	22	102
09	63	58	121	130	115	245	366
10	182	105	287	220	62	282	569
11	103	175	278	56	15	71	349
12	110	45	155	13	2	15	170
13	40	20	60	30	9	39	99
14	13	80	93	47	4	51	144
15	35	108	143	43	11	54	197
16	32	62	94	100	16	116	210
17	194	104	298	183	23	206	504
18	171	47	218	523	176	699	917
19	262	737	999	508	217	725	1724
20	115	527	642	102	81	183	825
21	216	293	509	47	157	204	713
22	59	101	160	10	41	51	211
23	39	323	362	22	47	69	431
24	28	147	175	11	79	90	265
25	37	413	450	4	84	88	538
26	69	581	650	18	70	88	738
27	10	125	135	5	10	15	150
28	3	3	6	42	23	65	71
29	8	36	44	3	5	8	52
30	11	104	115	28	22	50	165
31	35	90	125	33	10	43	168
01 September	42	41	83	394	33	427	510
Total	2675	4576	7251	3293	1463	4756	12007

Appendix A2.9. Daily catch of fourhorn sculpin by codend trap, Liverpool Bay, 1991.

	Number by station and side of trap						
	Station 601			Station 602			Grand
Date	01	02	Total	01	02	Total	Total
12 July						ND	0
13	1		1			ND	1
20						ND	0
21						ND	0
23						ND	0
24						ND	0
25	1		1			ND	1
26				1		1	1
27		1	1	1	2	3	4
28		4	4	1	4	5	9
29		3	3				3
30	1	2	3		4	4	7
31	2	6	8	3	5	8	16
01 August	1	6	7	2	6	8	15
02	1	4	5	3	7	10	15
03		2	2	4	5	9	11
04		1	1	7	1	8	9
05	12		12	6		6	18
06	15	6	21	4		4	25
07	5	8	13	4	1	5	18
08	4	2	6		2	2	8
09	1	1	2				2
10	10	8	18	4	1	5	23
11	19	7	26	1	1	2	28
12	1	9	10	4	2	6	16
13	5	3	8	6	9	15	23
14		4	4	4	8	12	16
15	1		1	2	1	3	4
16		1	1	1	1	2	3
17	4		4	3	1	4	8
18	1	1	2	1	1	2	4
19	3	4	7	10	1	11	18
20	2	1	3		2	2	5
21	2	2	4		2	2	6
22	5	1	6	6	5	11	17
23	2	2	4	4	2	6	10
24		1	1	4		4	5
25	1	2	3	3		3	6
26	2	6	8	1		1	9
27	1		1	1		1	2
28	1		1	2	2	4	5
29	1	6	7	1	2	3	10
30	2	1	3				3
31	1		1				1
01 September	2	1	3	1		1	4
Total	110	106	216	95	78	173	389

Appendix A2.10. Daily catch of rainbow smelt by codend trap, Liverpool Bay, 1991.

	Number by station and side of trap						
	Station 601			Station 602			Grand
Date	01	02	Total	01	02	Total	Total
12 July						ND	0
13						ND	0
20						ND	0
21						ND	0
23						ND	0
24	2		2			ND	2
25						ND	0
26							0
27	20	3	23	7		7	30
28	23	10	33	14	5	19	52
29	3		3	13		13	16
30				5	1	6	6
31		1	1	6		6	7
01 August	1	3	4	15	33	48	52
02				12	6	18	18
03	3	1	4	9	5	14	18
04	1	20	21	47	16	63	84
05	5	21	26	61	1	62	88
06	26	9	35	113	10	123	158
07	6	6	12	32	2	34	46
08	7	6	13	8	7	15	28
09	7	5	12	3	7	10	22
10	1	20	21	17	8	25	46
11	23	32	55	14	1	15	70
12	3	20	23	5	2	7	30
13	3		3	4	12	16	19
14		11	11	4	21	25	36
15	2	3	5	22	1	23	28
16		8	8	5		5	13
17	2	2	4	14	4	18	22
18	2		2	1		1	3
19	6		6	5	4	9	15
20	1	1	2	9	3	12	14
21		1	1	5	12	17	18
22		1	1	6	3	9	10
23		1	1	1	1	2	3
24	5	1	6	1	4	5	11
25	1	2	3		1	1	4
26	3		3	1	1	2	5
27		1	1	1	2	3	4
28				1		1	1
29		1	1	1		1	2
30	1	1	2				2
31		3	3	1		1	4
01 September		2	2				2
Total	157	196	353	463	173	636	989

Appendix A2.11. Daily catch of Pacific herring by codend trap, Liverpool Bay, 1991.

Date	Number by station and side of trap						Grand Total
	Station 601			Station 602			
	01	02	Total	01	02	Total	
12 July						ND	0
13						ND	0
20	2		2			ND	2
21	1		1			ND	1
23		9	9			ND	9
24	1	5	6			ND	6
25	5	2	7			ND	7
26							0
27	3	3	6	6		6	12
28	1	2	3	20		20	23
29				43	1	44	44
30				4	4	8	8
31	1		1	19		19	20
01 August	1		1	39	6	45	46
02	3	3	6	12	7	19	25
03	4	7	11	10	1	11	22
04	1	3	4	1		1	5
05					1	1	1
06					1	1	1
07	2	2	4				4
08	2		2		1	1	3
09	1	1	2	4		4	6
10							0
11							0
12	1		1	4		4	5
13	1	23	24	14	7	21	45
14	7	8	15	24	9	33	48
15	4	8	12	19	2	21	33
16	4	7	11	5	10	15	26
17	2	17	19	4	1	5	24
18	1	2	3	6	2	8	11
19		1	1	3		3	4
20	1		1	2	1	3	4
21		3	3		2	2	5
22					1	1	1
23	1		1	1	1	2	3
24		1	1	7		7	8
25				1	4	5	5
26	2	3	5		3	3	8
27		4	4		3	3	7
28	1	1	2	10	7	17	19
29	1	4	5		1	1	6
30		22	22	2	6	8	30
31	1	243	244	1	8	9	253
01 September	8	47	55	19	59	78	133
Total	63	431	494	280	149	429	923

Appendix A3.1. Daily trapnet catch of minor species at Station 601, Liverpool Bay, 1991.

	Number Captured by Species										
Date	INCO	BLPB	STFL	NSSB	ARCD	GLCD	CHAR	CPLN	PCSN	ARSC	TOTAL
12 July	1										1
13			2		3						5
20											0
21	1				1				2		4
23			1								1
24											0
25											0
26											0
27			1								1
28			1								1
29			1								1
30											0
31			1		1	1					3
01 August	1										1
02			1						1		2
03									8		8
04		7				1					8
05		2	2			1					5
06		7	6								13
07		1	2						1		4
08											0
09											0
10	1	1	2							1	5
11		11	1						1		13
12		2									2
13								2			2
14											0
15			2			1					3
16			1								1
17			2							1	3
18						3					3
19		2				5					7
20											0
21						3	1			1	5
22											0
23											0
24						1					1
25									3		3
26			2			1					3
27											0
28										1	1
29		1			2	3			13		19
30						3					3
31			1			1					2
01 September			1			2			1		4
Total	4	34	30	0	7	26	1	2	30	4	138

Appendix A3.2. Daily trapnet catch of minor species at Station 602, Liverpool Bay, 1991.

Date	Number Captured by Species										TOTAL
	INCO	BLPB	STFL	NSSB	ARCD	GLCD	CHAR	CPLN	PCSN	ARSC	
12 July											ND
13											ND
20											ND
21											ND
23											ND
24											ND
25											ND
26											0
27			1								1
28			1	1					1		3
29		1	1								2
30			1								1
31			1								1
01 August			2								2
02			3								3
03			1								1
04			1								1
05		1									1
06		2	1			2					5
07						1					1
08											0
09											0
10			1			2					3
11				1					1		2
12								1	1		2
13			1								1
14			1								1
15			4								4
16			1								1
17			1			1					2
18											0
19						1					1
20						2					2
21			2			3	1				6
22						1					1
23						3	1				4
24						2					2
25			1								1
26											0
27									12		12
28											0
29											0
30			1								1
31			1			1			1		3
01 September						3			1		4
Total	0	4	27	2	0	22	2	1	17	0	75

Appendix A4.1. Length-frequency distribution for measured sample of Arctic cisco by sampling cycle and side of trap at Station 601, Liverpool Bay, 1991.

Fork Length (mm)	Number by Sampling Cycle and Side of Trap[1]																Total	
	1		2		3		4		5		6		7		8			
	01	02	01	02	01	02	01	02	01	02	01	02	01	02	01	02	01	02
000-009																		
010-019																		
020-029																		
030-039																		
040-049																		
050-059						19		2										21
060-069					1	110		31				1		1			1	143
070-079					1	30		17		1		2	1	4	1		3	54
080-089					3	21		1		2			3	2			6	26
090-099					3	18	2	2		1		1		1			5	23
100-109					1	10				3			1				2	13
110-119							1			1			1	4		1	2	6
120-129					1												1	
130-139					3	3						1	1				4	4
140-149		1	3	2	18	11	5	9	2			1	4	9		6	32	39
150-159		2	6	3	46	22	25	12	1	6	2	1	13	36		5	93	87
160-169		3	17	2	70	22	19	11	2	10	2		19	40	4	5	133	93
170-179		13	72	12	150	26	22	12	1	4	2		12	45	2	7	261	119
180-189		8	90	14	102	7	13	19	3	1		4	20	74	1	7	229	134
190-199		4	90	16	70	12	13	9	2	8	4		19	69	2	9	200	127
200-209		4	72	13	41	11	3	9	5	2	1	1	21	44		5	143	89
210-219		3	87	25	17	5	4	7	5	3	1	1	16	23		2	130	69
220-229		1	74	21	20	14	4	6	14	6	5	3	9	23	1	4	127	78
230-239		3	63	17	10	10	4		8	1	7		6	23	1	1	99	55
240-249			33	11	8	5	2	2	8	5	3	2	14	21		1	68	47
250-259		2	25	11	4	7	1	1	3	4	2	1	4	14	2	1	41	41
260-269	1	6	15	13		5	2	2	1	7	1		7	10		4	27	47
270-279	1	1	15	19		8		1	5	3	4		3	14		1	28	47
280-289		2	17	17		8	1	4	4	4	3	1	1	8	1		27	44
290-299		2	13	19	1	9	3	3	2	4	5			9			24	46
300-309		5	9	21		3	1		3	12	6	1		4		1	19	47
310-319		2	19	21		10		1	3	10	12		2	3			36	47
320-329	2	2	12	31		18	1	3	6	13	10	1	3	2	2	4	36	74
330-339	1	4	17	29	1	16	5	4	9	9	6	2	3		1	3	43	67
340-349	5	3	18	39	3	27	2	5	11	10	10	4	5	1		1	54	90
350-359	6	4	13	50	5	30	8	15	11	11	12	5	6	5	1	1	62	121
360-369	3	2	19	48	3	36	9	8	21	17	14	2	6	3	3	3	78	119
370-379	4	1	11	42	5	33	6	7	22	6	6		1	3	1		56	92
380-389	3	1	5	31	5	18	3	7	8	3	4	2	3	5	1	1	32	68
390-399	3	1	4	17	1	12	1	2	4	3			1		1		15	35
400-409	3			10	1	5		3	1	2		1	1				6	21
410-419	1			5	1	1	1							1			3	7
420-429				1		2		1	1	1	1						2	5
430-439	1																1	
440-449																		
450-459								1										1
460-469						1												1
470-479																		
480-489																		
490-499																		
Total	34	80	819	560	595	605	161	217	166	173	123	38	206	501	25	73	2129	2247

Appendix A4.2. Length-frequency distribution for measured sample of Arctic cisco by sampling cycle and side of trap at Station 602, Liverpool Bay, 1991.

Fork Length (mm)	Number by Sampling Cycle and Side of Trap[1]																Total	
	1		2		3		4		5		6		7		8			
	01	02	01	02	01	02	01	02	01	02	01	02	01	02	01	02	01	02
000-009																		
010-019																		
020-029																		
030-039																		
040-049						3												3
050-059					3	90		10		1							3	101
060-069					8	144	3	53		12		14		14	1	4	12	241
070-079					1	16		21		20		25	4	61	1	29	6	172
080-089					7	14		2		7		11	1	25	2	15	10	74
090-099					15	9	3	3		5		1		5	4	1	22	24
100-109					8	5		1	2	6		3	2	10	3	5	15	30
110-119					1	1				3	1	1	5	12	2	9	9	26
120-129										2				4	4	3	4	9
130-139					5	1	4	2	1	1	2		2				14	4
140-149					24		19	5	10	2	6	1	1	6	1	2	61	16
150-159					28	7	27	5	9	7	12	1	14	8	5	3	95	31
160-169					43	5	17		15	3	12	2	6	15	1		94	25
170-179					101	10	15	9	4	2	9	4	8	8	2	3	139	36
180-189					98	5	19	2	10	5	14	4	18	13	2	6	161	35
190-199					81	4	8	1	12	1	9	4	11	10		5	121	25
200-209					58	2	13	1	7	2	8	1	11	7		4	97	17
210-219					40	5	4		7	2	11	1	10	3	1	4	73	15
220-229					51	2	2		14	1	9	3	15	1		3	91	10
230-239					46		4		16	3	11	1	13	2	3	1	93	7
240-249					28	1	3		13	2	9		28	1	1	1	82	5
250-259					40	2	1		10	3	3		19	1			73	6
260-269					31	2	3		6	2	6		25			2	71	6
270-279					26	1	2		8	2	6		18		2		62	3
280-289					14	1	5		3	2	2		25		1		50	3
290-299					6	1	1		9		2		27		1	1	46	2
300-309					9	2		1	5	1	3	1	28		1		46	5
310-319					9	2	1	2	15	2	9	2	17			1	51	9
320-329					14	9	3	3	8	3	9	2	29	1			63	18
330-339					10	5	2	5	13	4	12		43	2	2		82	16
340-349					16	6	7	7	24	3	22		34	1	3		106	17
350-359					22	12	3	6	28	5	31	3	49	1	2		135	27
360-369					20	15	10	8	39	1	16		40	1	1	1	126	26
370-379					32	11	11	2	14		13	1	30	1	4		104	15
380-389					20	9	5	5	10	2	12		14	1	2		63	17
390-399					11		3		3		6		7		1		31	
400-409						5	3		2		1		1		1		8	5
410-419					2		2	1			3		2				9	1
420-429					1						2						3	
430-439																		
440-449																		
450-459					1												1	
460-469																		
470-479																		
480-489																		
490-499																		
Total		ND		ND	930	407	203	155	317	117	271	86	557	214	54	103	2332	1082

Appendix A5.1. Length-frequency distribution for measured sample of saffron cod by sampling cycle at Station 601, Liverpool Bay, 1991.

Fork Length (mm)	Number by Sampling Cycle								Total	
	1	2	3	4	5	6	7	8	N	%
050-059										
060-069										
070-079										
080-089										
090-099										
100-109										
110-119										
120-129										
130-139					1				1	0.2
140-149							1		1	0.2
150-159										
160-169										
170-179								1	1	0.2
180-189					2	1	1	1	5	0.8
190-199				1	1	2	3	3	10	1.6
200-209				2	7	3	9	6	27	4.4
210-219				2	10	8	11	7	38	6.2
220-229				3	8	8	21	6	46	7.5
230-239				1	7	3	16	5	32	5.2
240-249				3	8	6	7		24	3.9
250-259				3	3	4	3	1	14	2.3
260-269					10	5	4		19	3.1
270-279					4	3	10	1	18	2.9
280-289				2	1	3	3	2	11	1.8
290-299				9	3	10	2	3	27	4.4
300-309			1	12	15	12	13	4	57	9.3
310-319			2	9	11	12	12	6	52	8.4
320-329			9	8	8	15	11	5	56	9.1
330-339			2	13	9	10	3	2	39	6.3
340-349			3	10	8	8	7	1	37	6.0
350-359			4	5	8	10	4	1	32	5.2
360-369			3	2	3	6	3	4	21	3.4
370-379			3	4	1	4	1	1	14	2.3
380-389			1	4	4	2	1		12	2.0
390-399			2		4	3			9	1.5
400-409			2		1	1	1		5	0.8
410-419			1		2	1			4	0.7
420-429						1			1	0.2
430-439					2	1			3	0.5
440-449										
450-459										
460-469										
470-479										
480-489										
490-499										
Total	ND	ND	33	93	141	142	147	60	616	

Appendix A5.2. Length-frequency distribution for measured sample of saffron cod by sampling cycle at Station 602, Liverpool Bay, 1991.

Fork Length (mm)	Number by Sampling Cycle								Total	
	1	2	3	4	5	6	7	8	N	%
050-059										
060-069										
070-079										
080-089				1					1	0.2
090-099							1		1	0.2
100-109										
110-119										
120-129										
130-139										
140-149										
150-159										
160-169										
170-179						4			4	0.8
180-189					1	2		3	6	1.1
190-199					1	5	6	3	15	2.8
200-209				6		9	8	4	27	5.1
210-219				2	2	17	10	11	42	7.9
220-229					5	5	11	5	26	4.9
230-239				3	2	11	3	3	22	4.1
240-249				2	5	8	5	4	24	4.5
250-259				2	2	1	3	3	11	2.1
260-269				3	2	1			6	1.1
270-279				4	3	1		3	11	2.1
280-289				2	5	4	4	3	18	3.4
290-299				7	13	7	3	1	31	5.8
300-309				8	12	8	7	2	37	6.9
310-319			3	12	7	7	10	4	43	8.0
320-329			1	11	16	12	6	6	52	9.7
330-339			2	8	10	7	5	5	37	6.9
340-349			1	8	10	8	6	2	35	6.5
350-359				1	10	8	3	2	24	4.5
360-369				3	2	4	2	1	12	2.2
370-379				1	8	6		1	16	3.0
380-389				1	4	1	4		10	1.9
390-399			1	4			1		6	1.1
400-409				1	1	3	3		8	1.5
410-419					3	1	2		6	1.1
420-429							1		1	0.2
430-439							1		1	0.2
440-449										
450-459										
460-469										
470-479					1	1			2	0.4
480-489										
490-499										
Total	ND	ND	8	90	125	141	105	66	535	

Appendix A5.3. Length-frequency distribution for measured sample of Pacific herring by sampling cycle at Station 601, Liverpool Bay, 1991.

Fork Length (mm)	Number by Sampling Cycle								Total	
	1	2	3	4	5	6	7	8	N	%
050-059										
060-069										
070-079										
080-089										
090-099										
100-109										
110-119										
120-129						2		1	3	1.4
130-139				1	2	1	1	3	8	3.6
140-149		1	1	3	4	7	1	2	19	8.6
150-159		2	1	5	5	9		5	27	12.3
160-169		5	1	6	14	6		4	36	16.4
170-179		3		4	17	2		5	31	14.1
180-189		4	1	3	3	1	3	7	22	10.0
190-199			2		1	1		4	8	3.6
200-209				1	1				2	0.9
210-219				1					1	0.5
220-229			1	1				1	3	1.4
230-239			1		2	1	2		6	2.7
240-249		2			3		3	3	11	5.0
250-259			1			2	5	2	10	4.5
260-269		1			2	1	7	1	12	5.5
270-279		1	1			3	5		10	4.5
280-289		1		1			2	1	5	2.3
290-299			1				3		4	1.8
300-309						1	1		2	0.9
310-319										
320-329										
330-339										
340-349										
Total	ND	20	11	26	54	37	33	39	220	

Appendix A5.4. Length-frequency distribution for measured sample of Pacific herring by sampling cycle at Station 602, Liverpool Bay, 1991.

Fork Length (mm)	Number by Sampling Cycle								Total	
	1	2	3	4	5	6	7	8	N	%
050-059				1					1	0.4
060-069										
070-079				1					1	0.4
080-089										
090-099										
100-109										
110-119										
120-129										
130-139					1	1		1	3	1.1
140-149			8	1	2	1		1	13	4.6
150-159			8	5	13	8	3	7	44	15.7
160-169			11	4	4	2	1	3	25	8.9
170-179			24	4	19	12	2	2	63	22.5
180-189			18	7	6	3	3	7	44	15.7
190-199			6	1	5	1		5	18	6.4
200-209			1		3		1	1	6	2.1
210-219			1		1				2	0.7
220-229			2	1	1	1		2	7	2.5
230-239			1	2		1			4	1.4
240-249			2		2	2	1	2	9	3.2
250-259			1	4	6		2	3	16	5.7
260-269			3		1	1	4	2	11	3.9
270-279			1	1	1	1	2		6	2.1
280-289						2	1	1	4	1.4
290-299							1		1	0.4
300-309							2		2	0.7
310-319										
320-329										
330-339										
340-349										
Total	ND	ND	87	32	65	36	23	37	280	

Appendix A5.5. Length-frequency distribution for measured sample of rainbow smelt by sampling cycle at Station 601, Liverpool Bay, 1991.

Fork Length (mm)	Number by Sampling Cycle 1	2	3	4	5	6	7	8	Total N	%
050-059										
060-069										
070-079			1						1	0.5
080-089										
090-099										
100-109						1			1	0.5
110-119				1		2			3	1.6
120-129										
130-139										
140-149										
150-159				7					7	3.7
160-169				5					5	2.7
170-179				6	4	1		1	12	6.4
180-189				7		1	2		10	5.3
190-199				7	5		1		13	6.9
200-209				8	6	2	1	1	18	9.6
210-219				7	8	4	2	2	23	12.2
220-229				4	16	2	2		24	12.8
230-239				7	10	3	2		22	11.7
240-249				4	5	5	2		16	8.5
250-259				3	8	2	3	1	17	9.0
260-269					4		1		5	2.7
270-279				1	2	2			5	2.7
280-289				2				2	4	2.1
290-299				1					1	0.5
300-309					1				1	0.5
310-319										
320-329										
330-339										
340-349										
Total	ND	ND	1	70	69	25	16	7	188	

Appendix A5.6. Length-frequency distribution for measured sample of rainbow smelt by sampling cycle at Station 602, Liverpool Bay, 1991.

Fork Length (mm)	Number by Sampling Cycle 1	2	3	4	5	6	7	8	Total N	%
050-059										
060-069					1				1	0.3
070-079				3	3				6	2.0
080-089					1				1	0.3
090-099					1				1	0.3
100-109			1						1	0.3
110-119			4	6	4				14	4.7
120-129			1	2	1				4	1.3
130-139			3	2	2	1			8	2.7
140-149				4	4	1			9	3.0
150-159			1		2	2			5	1.7
160-169			1	5	3	2			11	3.7
170-179				8	3	5			16	5.4
180-189			1	9	13	3	2	1	29	9.7
190-199			2	12	11	5			30	10.1
200-209			3	12	7	11			33	11.1
210-219			2	4	10	8	2		26	8.7
220-229			4	17	3	9	2		35	11.7
230-239			2	7	10	7	2		28	9.4
240-249			4	3	2	7	4		20	6.7
250-259			2	3	1	2	1		9	3.0
260-269			1	1		1	1		4	1.3
270-279			2						2	0.7
280-289			2		1				3	1.0
290-299			1			1			2	0.7
300-309										
310-319										
320-329										
330-339										
340-349										
Total	ND	ND	37	98	83	65	14	1	298	

Appendix A6. Length-frequency distribution for fish captured in gill nets at Liverpool Bay, 1991.

Length (mm)	ARCS[1] N	%	LSCS[1] N	%	BDWT[1] N	%	LKWT[1] N	%	INCO[1] N	%	SFCD[1] N	%	PCHR[1] N	%	ARFL[2] N	%	FHSC[2] N	%	STFL[2] N	%	RNSM[1] N	%	GLCD[1] N	%	ARSC[2] N	%	ASSC[2] N	%
050-059																														
060-069															1	4.8														
070-079																														
080-089																														
090-099																														
100-109															1	4.8			1	33.3										
110-119															2	9.5														
120-129															1	4.8									1	14.3				
130-139															1	4.8			1	33.3					1	14.3				
140-149																	1	3.7							1	14.3				
150-159															1	4.8					1	9.1			1	14.3				
160-169	1	0.4											1	1.3	1	4.8	1	3.7					1	12.5	1	14.3				
170-179	2	0.8											2	2.5			1	3.7					1	12.5	1	14.3	1	100.0		
180-189	5	2.0											1	1.3	1	4.8	3	11.1					3	37.5						
190-199	13	5.1									2	1.2	3	3.8	1	4.8	1	3.7			1	9.1								
200-209	2	0.8									4	2.3			2	9.5	4	14.8			1	9.1	1	12.5						
210-219	2	0.8									7	4.0	1	1.3	1	4.8	5	18.5			3	27.3	1	12.5						
220-229	2	0.8									3	1.7			1	4.8	5	18.5			1	9.1			1	14.3				
230-239	1	0.4									1	0.6	2	2.5			1	3.7			1	9.1								
240-249	1	0.4											1	1.3							2	18.2								
250-259	1	0.4									4	2.3	12	15.0			1	3.7					1	12.5						
260-269	1	0.4	1	100.0							4	2.3	13	16.3	1	4.8														
270-279	4	1.6											12	15.0			1	3.7												
280-289	2	0.8									5	2.9	15	18.8	4	19.0	1	3.7												
290-299	2	0.8									9	5.2	5	6.3	2	9.5					1	9.1								
300-309	5	2.0									13	7.5	6	7.5																
310-319	7	2.8									14	8.1	3	3.8																
320-329	6	2.4									17	9.8	3	3.8																
330-339	4	1.6									23	13.3																		
340-349	17	6.7									17	9.8																		
350-359	27	10.7									15	8.7																		
360-369	28	11.1									11	6.4																		
370-379	39	15.4									13	7.5																		
380-389	30	11.9									5	2.9																		
390-399	25	9.9															1	3.7												
400-409	8	3.2					1	25.0			4	2.3																		
410-419	7	2.8					1	25.0			2	1.2							1	33.3										
420-429	7	2.8					1	25.0																						
430-439	2	0.8																												
440-449	2	0.8																												
450-459																	1	3.7												
460-469																														
470-479							1	25.0																						
480-489																														
490-499																														
Total	253		1		1[3]		4		1[4]		173		80		21		27		3		11		8		7		1			

[1] Fork Length
[2] Total Length
[3] Length = 582 mm
[4] Length = 1001 mm