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Nearshore Distribution and Residency of Pink Salmon (*Oncorhynchus gorbuscha*) and Chum Salmon (*O. keta*) Fry and Their Predators in Auke Bay and Gastineau Channel, Southeast Alaska

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ERRATA NOTICE

NEARSHORE DISTRIBUTION AND RESIDENCY OF PINK SALMON (*Oncorhynchus gorbuscha*) AND CHUM SALMON (*O. keta*) FRY AND THEIR PREDATORS IN AUKE BAY AND GASTINEAU CHANNEL, SOUTHEAST ALASKA

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ABSTRACT

A total of 23,785 pink salmon (*Oncorhynchus gorbuscha*) and 51,462 chum salmon (*O. keta*) fry were sampled from mid-April to mid-June 1991 by beach seining at 12 sites in the nearshore estuarine waters of Auke Bay and Gastineau Channel, Southeast Alaska. Salmon fry dispersed rapidly from Gastineau Channel, but aggregated and reared more extensively in Auke Bay. The CPUE of salmon fry was higher in Auke Bay than Gastineau Channel. Pink salmon fry fork lengths were greater in Auke Bay than Gastineau Channel. Higher zooplankton abundance, higher water temperature, and slower currents in Auke Bay than in Gastineau Channel may have contributed to the larger pink salmon fry and higher abundance of pink and chum salmon fry in Auke Bay.

The recovery pattern of tagged chum salmon indicated that fish from the early May releases from Gastineau Hatchery and Sheep Creek Hatchery in Gastineau Channel migrated north over the Mendenhall River bar to reach Auke Bay. More tagged chum salmon fry were recovered in Auke Bay (133) than in Gastineau Channel (14); no tagged pink salmon was recovered in either location. Salmon fry from the late May releases did not use the nearshore environment as extensively as fry from early May releases, which suggests that later release timing of hatchery fish may minimize the potential for density-dependent interactions with fry from wild stocks in littoral habitats.

Predators of salmon fry totaled 854 coho salmon (*O. kisutch*) smolts, 769 chinook salmon (*O. tshawytscha*) smolts, 368 great sculpins (*Myoxocephalus* spp.) and Pacific staghorn sculpins (*Leptocottus armatus*), and 320 Dolly Varden (*Salvelinus malma*). Although chinook salmon smolts were equally distributed in Auke Bay and Gastineau Channel, the CPUE of coho salmon smolts, great sculpins, and staghorn sculpins was higher in Auke Bay. The CPUE of Dolly Varden was higher in Auke Bay than Gastineau Channel during peak salmon fry abundance in nearshore waters in May. Thus, in their migration from Gastineau Channel to the more productive waters of Auke Bay, salmon fry also moved from an area of low predation pressure to an area of higher predation pressure. In addition, the movement of fry from Gastineau Channel across the narrow, shallow Mendenhall River bar may have increased fry exposure to predation by birds and fish, before fry reached Auke Bay.

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INTRODUCTION

Early marine residency is a critical phase in the life history of Pacific salmon (*Oncorhynchus* spp.) that significantly affects year-class strength (Parker 1968; Walters et al. 1978; Bax 1983; Nichelson 1986). Pink salmon (*O. gorbuscha*) and chum salmon (*O. keta*) fry generally occupy nearshore estuarine waters for one to two months in the spring (Healey 1980). Growth during this early marine phase is extremely rapid (LeBrasseur and Parker 1964; Healey 1980), and is important to escape size-selective predation (Parker 1971; Hargreaves and LeBrasseur 1985; Mortensen et al. 1991).

The number of returning adult salmon varies among stocks, regions, and years. Some stocks exhibit high survival even in years of overall low return, whereas other stocks exhibit low survival in years of overall high return. In the Juneau area in southeastern Alaska, much lower marine survival has been observed for hatchery releases of both fed and unfed pink salmon from Sheep Creek into Gastineau Channel than for the wild population of pink salmon migrating from Auke Creek into Auke Bay (Fig. 1, Table 1). If early marine residency in nearshore waters influences such differences, then growth conditions or predation pressure during the nearshore phase of salmon fry should be different in these two locations.

The objective of this study was to compare Auke Bay and Gastineau Channel for (1) nearshore (within 40 m of shore) abundance of pink and chum salmon fry and their predators; (2) residency times of coded-wire-tagged (CWT) salmon; (3) mean fork length (FL) of pink salmon fry; and (4) environmental variables such as surface water temperature, salinity, clarity, wave action, and current.

METHODS

Study Area

Auke Bay and Gastineau Channel are situated near Juneau, about 80 km inland from the Gulf of Alaska, just north of the 58°N parallel in Southeast Alaska (Fig. 1). These two estuaries are separated by a large intertidal mudflat, which is navigable by small boat only at high tide. The tide in this region often fluctuates over 6 m. How much intermixing of water or fish occurs between these two locations is unknown. Six sites were sampled within 6 km of Auke Creek in Auke Bay, and six sites were sampled within 6 km of Sheep Creek in Gastineau Channel. Beach gradients varied between 3.2% and 15.8%, averaging 8.7% in Auke Bay and 9.2% in Gastineau Channel (Table 2). Surface substrate composition was visually classified according to the Wentworth scale (Buchanan and Kain 1984) into four categories: boulder (>256 mm); cobble (64–256 mm); pebble (4–64 mm); and granule (2–4 mm). Any substrate <2 mm, such as sand or mud, was also included in the granule category.

Sample Collection and Processing

The six sites were sampled weekly from mid-April to mid-June 1991 at tide levels ranging from +1.5 m to -0.3 m. Because of the time necessary to process large numbers of fish during periods of peak abundance, sometimes some sites could not be sampled within this tidal range. The order in which the sites were sampled was varied weekly so that if time constraints precluded sampling all sites, the same site would not always be omitted.

Fish were sampled with a beach seine. The entire 37-m-long beach seine was set 40 m from the shore parallel to shore using a 6.3-m skiff and 15-hp motor. Once the entire seine was unloaded into the water from the skiff, both wings were pulled simultaneously to the beach, and the seine was pulled ashore; each haul took approximately 15 minutes. The catch was enumerated by species. All salmon caught were passed through a CWT detector, and those with a CWT were retained on ice for later fork length and weight measurements, and for tag removal and reading. Up to 50 additional pink salmon per haul were also retained on ice for later fork length and weight measurements.

Five environmental variables were measured after each haul. At 0.5-m depth, water temperature and salinity were measured with a conductivity-temperature meter, current was measured with an electromagnetic flow meter, and wave height was measured with a meter stick. Water clarity was measured with a 0.25-m-diameter Secchi disc in 3-m-deep waters.

Up to 10 fish from each predator group per haul were sampled for length and stomach contents. Predator groups included coho (*O. kisutch*) and chinook (*O. tshawytscha*) salmon smolts, small (<200 mm) Dolly Varden (*Salvelinus malma*), large (≥200 mm) Dolly Varden, great sculpins (*Myoxocephalus* spp.), and Pacific staghorn sculpins (*Leptocottus armatus*). Only great sculpins >80 mm in total length and staghorn sculpins >130 mm in total length were sampled as predators. Analyses of stomach contents and fork length of predators have not been completed; this information will be summarized in a subsequent report.

Triplicate samples of pelagic zooplankton were collected weekly at each location with a 20-m vertical haul of a 0.5-m-diameter, 243-μm-mesh net. After a haul, a seawater pump was used to wash down the outside of the sampling net. The contents were then rinsed with filtered seawater and preserved in 5% formalin. Settled volumes were measured, and predominant organisms were identified. Similar samples were collected twice a week in Gastineau Channel by Douglas Island Pink and Chum, Inc. (DIPAC), personnel. DIPAC personnel measured only settled volumes; weekly samples from Gastineau Channel off Sheep Creek were analyzed by biologists from the Auke Bay Laboratory to compare the relationship of settled volume to abundance, and to compare the abundance and timing of zooplankton in Auke Bay to those in Gastineau Channel. These data are summarized in another report (Sturdevant and Landingham 1993).

Statistical Analysis

The univariate approach to analysis of variance (ANOVA) was used to analyze fish catch per unit effort (CPUE; number of fish per haul) and fork length and environmental data (Frane 1980). For each fully crossed analysis, the factors were location (Auke Bay and Gastineau Channel) and week; both factors were considered to be fixed factors. Each of the six sites per location was considered a replicate. Statistical distribution of CPUE was highly skewed because of a high number of zero catches. Transformations were not effective at eliminating this skewness. Thus, ranks of CPUE were used in the analysis of CPUE for each species separately. An ANOVA on ranks is conditionally distribution-free, usually has good efficiency, and the approximate level of significance used in the test is usually fairly close to the true level of significance, no matter what the underlying population distribution may be (Conover 1980). Graphical presentation of CPUE data is based on raw numbers. In the analysis of pink salmon mean fork length, the lengths approximated a normal distribution and were thus analyzed untransformed. In the analysis of environmental data, water temperature, salinity, clarity, and wave height were all approximately normally distributed and were thus analyzed untransformed. Current velocity was transformed by the natural log transformation to normalize the distribution and stabilize the variances.

Frequency of occurrence was analyzed as a measure of the patchiness of schools of salmon. Frequency of occurrence data were compared for differences between locations using a chi-square test for independence (Sokal and Rohlf 1981).

The hatchery contribution to total catch was estimated once a week from the number of CWTs for each tagged release group. Because not all fish released by the hatchery were tagged, the number of fish from each tag code recovered in a given week was expanded to account for the number of untagged fish released (Table 3). This number was also adjusted by the ratio of total tags to number of tags read in order to account for tags lost during processing. Thus, in Auke Bay, only 123 tags of 133 total tags were read, for a total-tags : tags-read ratio of 1.081. One of the 123 tags recovered in Auke Bay had an irreconcilable difference between the reported release date and our recovery date, so the tag was not used in determining contribution or distribution of tagged fish. In Gastineau Channel, only 9 tags of 14 total tags were read, for a total-tags : tags-read ratio of 1.556. A chi-square test for goodness of fit was used to analyze differences in the number of tagged fish caught at the two locations (Sokal and Rohlf 1981).

RESULTS

Total Catch

The total catch of juvenile salmon was 23,785 pink, 51,462 chum, 141 sockeye (*O. nerka)*, 854 coho, and 769 chinook salmon (Table 4). The total number of CWT fish caught was 147 chum, 19 sockeye, 81 coho, and 67 chinook salmon; no CWT pink salmon was recovered (Table 5). The chum salmon fry were released by DIPAC in early and late May from three locations in the Juneau area: Sheep Creek, Gastineau Hatchery, and Amalga Harbor (16 km north of Auke Bay) (Fig. 1, Table 3). The pink salmon fry were released only in late May from Gastineau Hatchery, although untagged hatchery-reared pink salmon were released in early May. The salmon smolts were released from many locations along the Pacific coast and Southeast Alaska.

Many non-salmonids were incidentally caught by the beach seine. We caught 320 Dolly Varden, of which 228 (71%) were ≥200 mm FL. A total of 909 Pacific sand lances (Ammodytidae), 552 flatfishes (Pleuronectidae), 368 great and Pacific staghorn sculpins (Cottidae), 280 Pacific herring (Clupeidae), 238 snake pricklebacks (Stichaeidae), 87 crescent gunnels (Pholidae), 56 smelts (Osmeridae), and 26 greenlings (Hexagrammidae) were also caught (Table 6).

Abundance and Size of Pink Salmon Fry

Pink salmon fry were more abundant and occurred more frequently in Auke Bay than in Gastineau Channel; pink salmon CPUE was 18 times higher in Auke Bay ($P < 0.001$, Table 7). Pink salmon occurred more frequently in Auke Bay (88%) than in Gastineau Channel (74%); this difference was marginally significant ($P < 0.1$).

The timing of pink salmon fry migrations differed at the two locations (Fig. 2). In Auke Bay there was a minor peak in CPUE in April. The catch then increased rapidly in the first week of May and peaked in mid-May. In Gastineau Channel, the CPUE was low except for a single peak in early May. In both locations, the CPUE declined to near zero the week after peak catches. The CPUE of pink salmon fry remained near zero at both locations after the late May release of hatchery fish (Fig. 2).

From mid–April to mid–June, pink salmon were larger overall in Auke Bay than Gastineau Channel. The mean fork length of pink salmon was significantly ($P < 0.001$) larger overall in Auke Bay, although mean fork length was similar in both locations until mid–May (Fig. 3). Mean fork length increased over time ($P < 0.001$) at both locations from about 34 mm in April to 55–60 mm in mid–June. During the peak CPUE of pink salmon fry in nearshore waters in mid–May, they averaged 40 mm FL in Auke Bay and 37 mm FL in Gastineau Channel.

Abundance of Chum Salmon Fry

Chum salmon fry were also significantly more abundant in Auke Bay than Gastineau Channel, although the frequency of occurrence was similar in both locations. Chum salmon CPUE was four times higher overall in Auke Bay ($P = 0.037$, Table 7). Chum salmon occurred just as frequently ($P > 0.1$) in Gastineau Channel (94%) as in Auke Bay (85%).

The CPUE for chum salmon fry peaked in mid–May in Auke Bay and in late May in Gastineau Channel. Few chum salmon were caught in nearshore waters of either location before May (Fig. 2). In Auke Bay, the CPUE of chum salmon fry peaked in mid–May, 2 weeks after the early release of hatchery fry. Some chum salmon remained in the nearshore waters of Auke Bay into June. In Gastineau Channel, the CPUE of chum salmon fry was uniformly low except in early and late May during the weeks immediately after the early and late releases, respectively, of hatchery fry.

Distribution of Coded–Wire–Tagged Chum Salmon

Most recoveries of CWT chum salmon consisted of fish from the early release groups recovered in Auke Bay. The number of recovered CWT chum salmon was significantly ($P < 0.01$) higher in Auke Bay (133) than in the lower portion of Gastineau Channel (14; Table 5). Most (92%) recoveries were from the early release groups (Table 8). The largest number of recoveries (97) was from the early release group from Gastineau Hatchery; these fish were recovered only in Auke Bay (Fig. 4). Tagged fish from the early release from Sheep Creek were also caught more frequently ($P < 0.01$) in Auke Bay (15) than in Gastineau Channel (4). Tagged fish from the late release of chum salmon from Gastineau Hatchery were caught in equal numbers in Auke Bay (1) and Gastineau Channel (1). From the late release at Sheep Creek, four CWT chum salmon were recovered in Gastineau Channel and one in Auke Bay. The chum salmon released from Amalga Harbor were recovered only in Auke Bay, four each from the early and late releases.

The number of CWT chum salmon caught indicated that most chum salmon in nearshore waters were hatchery fish (90% in Auke Bay and 81% in Gastineau Channel; Table 9).

After release from the different locations, CWT chum salmon showed up sooner in Gastineau Channel than Auke Bay. In Gastineau Channel, 78% of the recovered CWT chum salmon were recovered the first sampling week after release (Table 8). The CPUE of hatchery fish in Gastineau Channel peaked in early and late May, immediately after the early and late releases, respectively, of hatchery fish there. In contrast, only 26% of the CWT chum salmon recovered in Auke Bay were recovered the first week after release; 70% were caught the second week after release (Table 8). Peak CPUE of hatchery chum salmon in Auke Bay occurred in mid–May, the second week after the early release of hatchery fry. In both locations, peak catches of hatchery fish coincided with overall peak CPUE of all chum salmon fry (Fig. 2).

Abundance of Other Salmonids and Sculpins

Juvenile sockeye salmon were significantly more abundant in Auke Bay than Gastineau Channel, although frequency of occurrence was similar in both locations (Fig. 5; Table 7). Sockeye salmon CPUE was four times[1] as high in Auke Bay as in Gastineau Channel (P = 0.008; Table 7). Sockeye salmon, however, occurred just as frequently ($P > 0.1$) in Gastineau Channel (15%) as in Auke Bay (27%). Juvenile sockeye salmon did not appear in the nearshore waters of either location before June; CPUE was at or near seasonal highs when sampling was terminated in mid-June.

Juvenile coho salmon were also significantly more abundant in Auke Bay than Gastineau Channel[2], although frequency of occurrence was similar in both locations (Fig. 5). Coho salmon CPUE was twice as high in Auke Bay as in Gastineau Channel (P = 0.001, Table 7). Coho salmon occurred just as frequently ($P > 0.1$) in Gastineau Channel (30%) as Auke Bay (44%).

In contrast to the other salmon species, chinook salmon smolts were evenly distributed in Auke Bay and Gastineau Channel (Fig. 5). Neither CPUE nor frequency of occurrence of chinook salmon differed significantly ($P > 0.1$) between Auke Bay and Gastineau Channel (Table 7).

Juvenile sockeye, coho, and chinook salmon exhibited similar timing of migration from mid-April to mid-June (Fig. 5). Coho salmon smolts first appeared in nearshore waters in late May, and sockeye and chinook salmon smolts in early June. At both locations, the CPUE of sockeye, coho, and chinook salmon was uniformly high during our last sampling period in mid-June.

Both large and small Dolly Varden were similarly distributed in Auke Bay and Gastineau Channel. Neither CPUE nor frequency of occurrence of large or small Dolly Varden was significantly ($P > 0.1$) different overall in the two locations (Table 7). However, during peak catches in early and mid-May, the CPUE of both small and large Dolly Varden was higher in Auke Bay than Gastineau Channel (Fig. 6). In both locations, the largest catches of large Dolly Varden occurred in May, the same month as the largest catches of pink and chum salmon fry in nearshore waters. In both locations, large Dolly Varden continued to be present in nearshore waters in small numbers until sampling was terminated in mid-June. In Auke Bay, the CPUE of small Dolly Varden also peaked in mid-May, the same as CPUE of pink and chum salmon fry. In Gastineau Channel, however, the CPUE of small Dolly Varden did not peak until early June, several weeks after the peak of salmon fry abundance.

Great sculpins and Pacific staghorn sculpins were significantly more abundant and occurred more frequently in Auke Bay than Gastineau Channel. Both types of sculpin had about 4 times higher ($P < 0.01$) CPUE in Auke Bay (Table 7) and occurred almost 3 times more frequently there ($P < 0.01$).

The seasonal timing of great and Pacific staghorn sculpins differed in Auke Bay and Gastineau Channel (Fig. 7). In Gastineau Channel their CPUE peaked in June. In Auke Bay the CPUE of great sculpins peaked in April, and of staghorn sculpins in late May.

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[1]Actual CPUE was 2.3 in Auke Bay and 0.54 in Gastineau Channel. The reported CPUEs were rounded to 2 and 1.

[2]Although the actual CPUE was 6 in Auke Bay and 11 in Gastineau Channel, the ANOVA was run on ranked CPUE, which was 55 in Auke Bay and 45 in Gastineau Channel.

Physical Environment

The physical environments of Auke Bay and Gastineau Channel were different (Table 10). Water temperature, salinity, and clarity were all significantly ($P < 0.05$) higher in Auke Bay (Table 10; Figs. 8, 9). Water temperature peaked in early May in Gastineau Channel and in late May in Auke Bay. At both locations, salinity decreased over the course of the season. Water clarity was highest in mid-April in Gastineau Channel and in early May in Auke Bay. Wave action at the two locations did not differ significantly ($P > 0.1$), but nearshore surface currents were significantly ($P = 0.008$) stronger in Gastineau Channel.

DISCUSSION

Salmon fry moved rapidly through Gastineau Channel. The catch pattern of pink and chum salmon fry and the distribution of CWT chum salmon indicated a short residency for salmon fry there. Abundance of both pink and chum salmon fry in Gastineau Channel was consistently low over time. The CPUE of pink salmon peaked once in early May, immediately after the early release of pink salmon fry from Gastineau and Sheep Creek hatcheries, and the CPUE of chum salmon fry peaked in early May and late May, the weeks immediately after the early and late releases, respectively, of hatchery fry. Most tagged chum salmon recovered in Gastineau Channel were recovered within a few days of release.

In contrast, pink and chum salmon fry reared more extensively in Auke Bay: their residency in nearshore waters was more prolonged there than in Gastineau Channel. Pink salmon fry first appeared in the nearshore waters of Auke Bay in late April; their CPUE peaked in mid-May, but a small number were present through June. This pattern is consistent with previous research on how juvenile pink salmon use Auke Bay: fry abundance nearshore typically peaks in mid-May, and residencies of several weeks have been documented for CWT Auke Creek fry in Auke Bay (Taylor et al. 1987; Mortensen and Wertheimer 1988). Chum salmon fry first appeared in the nearshore waters of Auke Bay in early May, and a few were caught there through June. Tagged fry from Gastineau Channel and Amalga Harbor releases were caught in Auke Bay, which indicates they immigrated into the bay from both the north and the south.

To reach Auke Bay, chum salmon released from Gastineau Hatchery probably moved northward over the Mendenhall River bar rather than migrating south out of Gastineau Channel and around Douglas Island. A large number of tagged chum salmon from the early release from Gastineau Hatchery were recovered in Auke Bay shortly after release. More CWT chum salmon from the early release at Sheep Creek Hatchery were also recovered in Auke Bay than in Gastineau Channel, some within a week of release, which suggests that at least a portion of the fish from this release also moved out of Gastineau Channel to the north, over the bar and into Auke Bay. The lower recovery rates for Sheep Creek chum salmon in Auke Bay relative to Gastineau Hatchery fish may be due to several factors: emigration—by some portion of the release—south from Gastineau Channel, higher predation associated with the longer migration distance from Sheep Creek to Auke Bay, or more rapid movement of the Sheep Creek fish out of the nearshore environment due to their larger size at release (Table 3).

Several factors may contribute to greater use of Auke Bay than Gastineau Channel as a rearing area for both pink and chum salmon fry and may explain the larger fork length of pink salmon fry in Auke Bay. In 1991, zooplankton were more dense in Auke Bay than in Gastineau Channel, and the major bloom was earlier and longer in Auke Bay (Sturdevant and Landingham 1993). Water temperature, salinity, and clarity were generally lower in Gastineau Channel, indicating more influence from glacial run-off, which may reduce light penetration and primary production in the channel. Nearshore currents were also stronger at the Gastineau Channel sites; these currents were strongest during May, when the majority of salmon fry occupied nearshore waters. Beaches with strong lateral currents have previously been characterized as transition beaches, waters through which juvenile salmon are likely to move rapidly rather than holding and rearing for an extended period (Celewycz 1984; Jaenicke et al. 1984). We observed large aggregations of pink and chum salmon fry in May in the three boat harbors in Gastineau Channel. These harbors may be refuges from the strong currents sweeping the beaches of the channel itself.

Salmon fry from the hatchery releases in late May did not occupy the nearshore environment as much as fry from the releases in early May. The CPUE of pink salmon in Auke bay dropped quickly by late May, and no tagged pink salmon released in late May was recovered in nearshore waters. This shift from nearshore to deeper waters in late May has been observed for pink salmon in Auke Bay (Taylor et al. 1987; Mortensen and Wertheimer 1988). The low CPUE of chum salmon in late May and early June and the few late-release tags recovered indicates that most chum salmon fry also had left the nearshore environment by late May. Late releases may minimize the potential of density-dependent interactions with fry from wild stocks during the nearshore phase and avoid the increasing numbers of predators in nearshore waters.

Salmon fry migrating from Gastineau Channel to Auke Bay moved from low to high predation areas. Great sculpins and Pacific staghorn sculpins were significantly more abundant in Auke Bay. The CPUE of both large and small Dolly Varden was higher in Auke Bay than in Gastineau Channel when fry were most abundant nearshore in mid-May. In contrast, large catches of coho and chinook smolts did not occur until June, after most pink and chum salmon fry had already moved from the nearshore. Taylor et al. (1987) and Mortensen et al. (1991) have speculated that the offshore movement of salmon fry may be timed to avoid the increasing concentrations of predators in nearshore waters. Although this may be the case with the salmon smolts that did not appear in nearshore waters until late May or June, peak catches of both large and small Dolly Varden in Auke Bay coincided with peak catches of pink and chum salmon fry, suggesting that these predators may be focusing on aggregations of fry during their nearshore phase. In addition, the rapid northward movement of fry from Gastineau Channel across the Mendenhall River bar may expose the migrating fry to high rates of predation before the fish reach Auke Bay. The Mendenhall River bar is very narrow and shallow, especially at low tide, and the extreme tidal fluctuation may concentrate the fry into a small volume of water, thus exposing them to piscan and avian predators. We observed large aggregations of seabirds, including Bonaparte's gull (*Larus philadelphia*), Arctic tern (*Sterna paradisaea*), and marbled murrelet (*Brachyramphus marmoratus*), feeding at the northern end of the bar. This area should be examined as a potential survival bottleneck for pink and chum salmon fry leaving Gastineau Channel.

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TABLES

Table 1.—Number released and percent return of pink salmon at Auke Creek[a] and Sheep Creek[b] Hatcheries, brood years 1980–89. Auke Creek fish include wild pink salmon only.

	Auke Creek		Gastineau Channel[c]	
Brood year	Fry released	Return (%)	Fry released (millions)	Return (%)
1980	83,526	8.3	1.14	0.53
1981	111,416	9.8	9.00	0.89
1982	164,784	3.1	14.49	0.37
1983	169,552	14.2	32.01	1.34
1984	110,000	1.9	14.94	0.13
1985	70,459	10.1	35.70	2.16
1986	26,253	26.9	8.40	0.24
1987	74,912	6.0	29.80	0.16
1988	74,170	26.1	15.00[d]	0.39
1989	98,355	6.8	9.67[d]	0.85
1989	–	–	17.96[e]	1.45

[a]Source: J. Taylor, Supervisory fisheries research biologist, Auke Bay Laboratory, NMFS, unpublished data, February 1991.

[b]Sources: DIPAC Technical Review Committee (1990); R. Mattson, Hatchery manager, DIPAC, unpublished data, June 1991.

[c]Releases before 1988 were only at Sheep Creek.

[d]Gastineau Hatchery releases.

[e]Sheep Creek releases.

Table 2.—Beach seine sample site characteristics, grade, and substrate in Gastineau Channel (surveyed 15 April 1991) and Auke Bay (surveyed 16 April 1991). Grades were shot at a tide level from −0.62 m to +1.5 m. The grade at the right side of each site (R) was averaged with the grade at the left side of each site (L) to obtain the mean grade. Substrates were characterized from −0.9–m to +1.5–m tide level. The presence of mussel clumps was also noted.

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1. Gastineau Channel

Cross Bay Creek (cb)
Grade: R = 9.2%, L = 15.8%, Mean = 12.5%
Substrate: −0.9 to −0.3 m: predominately granule, scattered cobble/pebble/mussel clumps
−0.3 to +0.3 m: granule/cobble/pebble
+0.3 to +0.9 m: cobble
+0.9 to +1.5 m: cobble with scattered small boulders

Sheep Creek (sc)
Grade: R = 7.4%, L = 9.0%, Mean = 8.2%
Substrate: −0.9 to +1.5 m: uniformly granule

Little Sheep (ls)
Grade: R = 12.6%, L = 11.2%, Mean = 11.9%
Substrate: −0.9 to +0.3 m: small boulder, cobble
+0.3 to +1.5 m: small boulder/cobble/pebble

Lucky Me (lm)
Grade: R = 5.2%, L = 5.6%, Mean = 5.4%
Substrate: −0.9 to +1.5 m: uniform pebble with 10–20% cobble

Stump Beach (sb)
Grade: R = 3.9%, L = 3.2%, Mean = 3.6%
Substrate: −0.9 to +0.3 m: predominately granule, 15% pebble
+0.3 to +1.5 m: predominately pebble, scattered cobbles

Ready Bullion (rb)
Grade: R = 13.7%, L = 13.8%, Mean = 13.8%
Substrate: −0.9 to −0.3 m: granule
−0.3 to +1.5 m: cobble/mussel clumps

Table 2.—Continued.

2. Auke Bay

Fred's Beach (fb)
Grade: R = 12.4%, L = 9.8%, Mean = 11.1%
Substrate: -0.9 to +1.5 m: uniform granule/pebble

Reischel's Dock (rd)
Grade: R = 8.4%, L = 8.8%, Mean = 8.6%
Substrate: -0.9 to +0.3 m: granule, with scattered pebbles and small cobbles
+0.3 to +1.5 m: granule/pebble/cobble

Old Spuhn (os)
Grade: R = 5.2%, L = 6.0%, Mean = 5.6%
Substrate: -0.9 to +0.3 m: predominately granule, with scattered cobbles
+0.3 to +1.5 m: granule/pebble/cobble

Coghlan Island (ci)
Grade: R = 7.5%, L = 7.7%, Mean = 7.6%
Substrate: -0.9 to +0.3 m: predominately granule, scattered cobbles
+0.3 to +1.5 m: pebble/cobble

Nerka Beach (Indian Island) (nb)
Grade: R = 15.0%, L = 15.4%, Mean = 15.2%
Substrate: -0.9 to +1.5 m: uniform pebble/cobble

Auke Nu Delta (ad)
Grade: R = 4.0%, L = 4.0%, Mean= 4.0%
Substrate: -0.9 to +1.5 m: uniform granule/pebble/cobble

Table 3.—Release date, release size, and number of coded-wire-tagged chum and pink salmon fry released from DIPAC facilities in 1991. The total number of fry represented by the tagged fish and the associated tag expansion ratio are also shown.

Release site	Release date	Release size (g)	Number tagged	Total release	Expansion factor
			Chum salmon		
Sheep Creek	3 May	0.98	28,344	18,045,214	637.5
	18 May	1.57	28,178	19,772,300	702.7
Gastineau Hatchery	3 May	0.78	29,290	5,677,903	193.9
	20 May	1.45	28,142	5,648,681	200.7
Amalga Harbor	5 May	0.62	30,431	18,987,184	624.9
	18 May	1.13	30,405	15,696,091	517.3
			Pink salmon		
Gastineau Hatchery	22 May	0.56	31,434	4,925,564	156.7
	22 May	0.61	28,091	5,043,474	179.5

Table 4.—CPUE of salmonids by week in Auke Bay and Gastineau Channel, April–June 1991. Auke Bay sites were Auke Nu Delta (ad), Coghlan Island (ci), Fred's Beach (fb), Nerka Beach (nb), Old Spuhn (os), and Reischel's Dock (rd). Gastineau Channel sites were Cross Bay Creek (cb), Lucky Me (lm), Little Sheep (ls), Ready Bullion (rb), Stump Beach (sb), and Sheep Creek (sc).

		CPUE					
Date	Site	Pink salmon	Chum salmon	Sockeye salmon	Coho salmon	Chinook salmon	Dolly Varden
				Auke Bay			
April							
18	ad	0	0	0	0	0	0
18	ci	29	11	0	0	0	0
18	fb	5	3	0	0	0	0
18	nb	2	0	0	0	0	0
18	os	1	0	0	0	0	0
18	rd	99	113	0	0	0	0
24	ad	42	5	0	0	0	0
24	ci	42	22	0	0	0	0
24	fb	3	8	0	0	0	0
24	nb	121	4	0	0	0	0
24	os	1,741	482	0	0	0	0
24	rd	1	1	0	0	0	0
May							
01	ad	1	3	0	0	0	0
01	ci	24	58	0	0	0	0
01	fb	0	0	0	0	0	0
01	nb	0	0	0	0	0	0
01	os	0	3	0	0	0	6
01	rd	15	28	0	0	0	0
08	ad	48	266	0	0	0	0
08	ci	5,232	560	0	0	0	0
08	fb	2	0	0	0	0	3
08	nb	1,173	513	0	0	0	0
08	rd	1,135	7,500	0	0	0	33
15	ad	1	18	0	0	0	2
15	fb	52	924	0	0	0	0
15	nb	1,580	1,835	0	0	0	2
15	os	7,035	2,961	0	1	0	2
15	rd	2,976	18,656	0	2	0	63
22	ad	14	281	0	1	1	5
22	fb	109	365	0	11	0	0
22	os	113	1,498	0	4	0	0
22	rd	72	1,321	0	4	0	1

Table 4.—Continued.

Date	Site	CPUE Pink salmon	Chum salmon	Sockeye salmon	Coho salmon	Chinook salmon	Dolly Varden
May							
28	ad	44	284	0	1	0	1
28	fb	2	92	9	55	0	11
28	nb	10	18	1	2	0	6
28	os	0	6	0	0	0	0
28	rd	9	498	2	15	0	8
June							
05	ad	22	418	15	15	27	13
05	ci	9	36	2	21	10	0
05	nb	159	323	6	11	12	0
05	os	24	1,184	16	7	8	1
05	rd	4	91	7	10	9	0
12	ad	17	106	2	45	141	35
12	ci	21	31	4	20	45	1
12	fb	148	62	23	14	39	0
12	nb	260	196	22	1	6	0
12	os	6	53	3	6	9	10
12	rd	0	0	0	20	44	2
Auke Bay total		22,403	40,837	112	266	351	205
			Gastineau Channel				
April							
17	cb	0	2	0	0	0	0
17	lm	1	1	0	0	0	0
17	ls	15	398	0	0	0	0
17	rb	0	106	0	0	0	0
17	sb	0	3	0	0	0	0
17	sc	0	20	0	0	0	0
23	cb	1	203	0	0	0	1
23	lm	45	41	0	0	0	0
23	ls	28	344	0	0	0	0
23	rb	2	6	0	0	0	0
23	sb	4	14	0	0	0	1
23	sc	0	1	0	0	0	0
30	cb	1	15	0	0	0	0
30	lm	24	30	0	0	0	0
30	ls	7	12	0	0	0	0
30	rb	21	311	0	0	0	0
30	sb	2	1	0	0	0	0
30	sc	0	1	0	0	0	0

Table 4.—Continued.

Date	Site	CPUE Pink salmon	Chum salmon	Sockeye salmon	Coho salmon	Chinook salmon	Dolly Varden
May							
07	cb	359	387	0	0	0	1
07	lm	356	247	0	0	0	1
07	ls	0	3	0	0	0	12
07	rb	64	177	0	0	0	0
07	sb	7	15	0	0	0	0
07	sc	176	662	0	0	0	0
14	cb	41	154	0	0	0	0
14	lm	0	0	0	0	0	1
14	ls	19	100	0	0	0	0
14	rb	8	21	0	0	0	0
14	sb	24	72	0	0	0	1
14	sc	0	1	0	0	0	2
21	cb	8	1,088	0	0	1	0
21	lm	0	47	0	0	0	7
21	ls	0	2,346	0	0	0	0
21	rb	4	56	0	0	0	1
21	sb	1	276	0	0	0	4
21	sc	33	2,651	0	0	0	4
29	cb	2	31	0	2	13	3
29	lm	2	0	0	2	1	8
29	ls	18	86	9	99	13	0
29	rb	1	4	0	0	0	0
29	sb	1	62	1	26	10	10
29	sc	54	437	1	3	0	6
June							
04	cb	1	0	0	2	4	3
04	lm	12	27	1	11	3	18
04	ls	1	11	0	1	2	6
04	rb	18	57	0	0	0	0
04	sb	4	18	0	1	1	1
04	sc	6	21	0	6	1	0
11	cb	1	1	0	59	24	2
11	lm	0	1	2	38	10	7
11	ls	0	1	0	117	240	1
11	rb	8	29	7	9	12	1
11	sb	2	18	4	159	67	13
11	sc	0	9	4	53	16	0
Gastineau Channel total		1,382	10,625	29	588	418	115
Grand total		23,785	51,462	141	854	769	320

Table 5.—Summary of coded-wire-tagged juvenile salmon recovered in Auke Bay and Gastineau Channel, April–June 1991.

Location	Pink salmon	Chum salmon	Sockeye salmon	Coho salmon	Chinook salmon
Auke Bay	0	133	19	40	37
Gastineau Channel	0	14	0	41	30

Table 6.—Fish caught at six sites in Auke Bay and six sites in Gastineau Channel, April–June 1991. Auke Bay sites were Auke Nu Delta (ad), Coghlan Island (ci), Fred's Beach (fb), Nerka Beach (nb), Old Spuhn (os), and Reischel's Dock (rd). Gastineau Channel sites were Cross Bay Creek (cb), Lucky Me (lm), Little Sheep (ls), Ready Bullion (rb), Stump Beach (sb), and Sheep Creek (sc).

	Site						
Species or family	ad	ci	fb	nb	os	rd	Total
(A) Auke Bay							
Salmonids							
Pink salmon	189	5,357	321	3,305	8,920	4,311	22,403
Chum salmon	1,381	718	1,454	2,889	6,187	28,208	40,837
Sockeye salmon	17	6	32	29	19	9	112
Coho salmon	62	41	80	14	18	51	266
Chinook salmon	169	55	39	18	17	53	351
Dolly Varden	56	1	14	8	19	107	205
Incidentals							
Cottidae	54	47	25	19	35	74	254
Clupeidae	4	3	236	1	1	1	246
Osmeridae	0	1	2	24	1	1	29
Ammodytidae	0	691	75	0	112	10	888
Pholidae	11	3	1	5	18	16	54
Stichaeidae	5	30	0	6	71	75	187
Pleuronectidae	55	65	25	10	196	139	490
Hexagrammidae	17	0	2	2	0	0	21

	Site						
Species or family	cb	lm	ls	rb	sb	sc	Total
(B) Gastineau Channel							
Salmonids							
Pink salmon	414	440	88	126	45	269	1,382
Chum salmon	1,881	394	3,301	767	479	3,803	10,625
Sockeye salmon	0	3	9	7	5	5	29
Coho salmon	63	51	217	9	186	62	588
Chinook salmon	42	14	255	12	78	17	418
Dolly Varden	10	42	19	2	30	12	115
Incidentals							
Cottidae	4	8	38	18	46	0	114
Clupeidae	6	1	18	2	4	3	34
Osmeridae	304	9	2	1	8	3	327
Ammodytidae	15	0	0	0	0	6	21
Pholidae	3	0	9	19	2	0	33
Stichaeidae	1	20	8	7	15	0	51
Pleuronectidae	5	4	18	11	3	21	62
Hexagrammidae	1	1	1	1	1	0	5

Table 7.—Abundance of pink and chum salmon fry and their potential predators in Auke Bay (48 seine hauls) and Gastineau Channel (54 seine hauls), April–June 1991, as measured by CPUE and frequency of occurrence (FO); FO (%) represents the percentage of hauls in which a species occurred. CPUE was analyzed with ANOVA on ranked CPUE, and FO (%) was analyzed with a chi-square test for independence.

		Location		
Species	Parameter	Auke Bay	Gastineau Channel	Significance
Pink salmon	CPUE	467	26	***
	FO (%)	88	74	*
Chum salmon	CPUE	851	197	**
	FO (%)	85	94	n.s.
Sockeye salmon	CPUE	2	1	***
	FO (%)	27	15	n.s.
Coho salmon	CPUE	6	11	***
	FO (%)	44	30	n.s.
Chinook salmon	CPUE	7	8	n.s.
	FO (%)	25	30	n.s.
Small Dolly Varden	CPUE	3	2	n.s.
	FO (%)	33	31	n.s.
Large Dolly Varden	CPUE	1	1	n.s.
	FO (%)	27	26	n.s.
Pacific staghorn sculpin	CPUE	2	1	***
	FO (%)	54	20	***
Great sculpin	CPUE	1	0	***
	FO (%)	54	20	***

n.s. not significant.
* $0.050 < P < 0.100$.
** $0.010 < P < 0.050$.
*** $P < 0.010$.

Table 8.—Recovery date, number of tags, and estimated number of chum salmon fry from DIPAC hatchery releases caught in Auke Bay and Gastineau Channel in 1991. To estimate total hatchery fry, tag recoveries were expanded by 1.081 (Auke Bay) and 1.556 (Gastineau Channel) to account for lost tags, and by the untagged/tagged release ratio for the tag group (Table 3).

Release group	Recovery date	Auke Bay		Gastineau Channel	
		Tags	Est. no.	Tags	Est. no.
Sheep Creek early release	May 7-8	4	2,756	3	2,976
	May 14-15	11	7,581	0	0
	May 28-29	0	0	1	992
	Total	15	10,337	4	3,968
Sheep Creek late release	May 21-22	0	0	4	4,374
	Jun 4-5	1	760	0	0
	Total	1	760	4	4,374
Gastineau Hatchery early release	May 7-8	18	3,773	0	0
	May 14-15	70	14,672	0	0
	May 21-22	6	1,258	0	0
	May 28-29	2	419	0	0
	Jun 11-12	1	210	0	0
	Total	97	20,332	0	0
Gastineau Hatchery late release	May 28-29	0	0	1	312
	Jun 4-5	1	217	0	0
	Total	1	217	1	312
Amalga Harbor early release	May 7-8	1	676	0	0
	May 14-15	3	2,027	0	0
	Total	4	2,703	0	0
Amalga Harbor late release	May 21-22	3	1,678	0	0
	Jun 4-5	1	559	0	0
	Total	4	2,237	0	0

Table 9.—Estimated number of DIPAC-tagged chum salmon fry (Hatch), total catch of chum salmon fry, and proportion of hatchery chum salmon to total catch (%Hatch) caught in Gastineau Channel and Auke Bay, April–June 1991.

	Auke Bay catch			Gastineau Channel catch		
Date	Hatch	Total	%Hatch	Hatch	Total	%Hatch
17-18 Apr	0	127	0.0	0	530	0.0
23-24 Apr	0	522	0.0	0	609	0.0
30 Apr- 1 May	0	92	0.0	0	370	0.0
7-8 May	7,205	8,839	81.5	2,976	1,491	100.0
14-15 May	24,280	24,394	99.5	0	348	0.0
21-22 May	2,936	3,465	84.7	4,374	6,464	67.7
28-29 May	419	898	46.7	1,304	620	100.0
4-5 Jun	1,536	2,052	74.9	0	134	0.0
11-12 Jun	210	448	46.9	0	59	0.0
Total	36,586	40,837	89.6	8,654	10,625	81.4

Table 10.—Environmental variables measured in Auke Bay and Gastineau Channel, April–June 1991. Auke Bay sites were Auke Nu Delta (ad), Coghlan Island (ci), Fred's Beach (fb), Nerka Beach (nb), Old Spuhn (os), and Reischel's Dock (rd). Gastineau Channel sites were Cross Bay Creek (cb), Lucky Me (lm), Little Sheep (ls), Ready Bullion (rb), Stump Beach (sb), and Sheep Creek (sc). Dash indicates that no sample was collected.

		Environmental variables				
Date	Site	Water temperature (°C)	Salinity (‰)	Secchi depth (cm)	Wave height (cm)	Current (cm/s)
			Auke Bay			
April						
18	ad	6.0	27.2	250	1	7
18	ci	5.4	28.4	250	1	0
18	fb	5.8	28.8	200	4	0
18	nb	5.5	29.2	300	1	0
18	os	5.0	29.2	400	1	1
18	rd	5.5	29.2	250	0	3
	Mean	5.5	28.7	275	1	2
24	ad	9.2	25.3	100	16	7
24	ci	6.5	29.0	150	8	2
24	fb	8.0	27.5	250	7	3
24	nb	6.9	28.8	200	2	0
24	os	7.6	25.7	300	1	3
24	rd	8.6	27.6	300	4	1
	Mean	7.8	27.3	217	6	3
May						
01	ad	6.2	25.9	250	6	2
01	ci	5.8	26.8	200	2	1
01	fb	6.3	26.7	200	2	3
01	nb	6.0	26.2	200	0	5
01	os	5.8	27.1	150	0	0
01	rd	6.1	26.8	200	2	3
	Mean	6.0	26.6	200	2	2
08	ad	8.9	23.3	400	6	1
08	ci	9.6	27.2	350	2	2
08	fb	10.4	24.6	300	1	1
08	nb	8.7	27.3	300	1	3
08	rd	11.1	25.9	250	1	3
	Mean	9.7	25.7	320	2	2

Table 10.—Continued.

Date	Site	Environmental variables: Water temperature (°C)	Salinity (‰)	Secchi depth (cm)	Wave height (cm)	Current (cm/s)
May						
15	ad	8.0	23.3	200	4	4
15	fb	7.9	23.7	200	4	4
15	nb	7.9	23.3	200	6	3
15	os	8.9	23.4	150	1	3
15	rd	8.2	23.7	100	1	2
	Mean	8.2	23.5	170	3	3
22	ad	9.2	19.5	200	6	2
22	fb	13.0	18.5	200	5	1
22	os	13.8	19.2	200	1	0
22	rd	12.1	19.8	200	3	2
	Mean	12.0	19.3	200	4	1
28	ad	9.5	23.7	—	17	0
28	fb	9.8	23.7	250	10	1
28	nb	9.5	23.3	250	14	6
28	os	8.6	24.9	250	3	3
28	rd	9.1	24.5	250	3	1
	Mean	9.3	24.0	250	9	2
June						
05	ad	10.4	21.4	—	5	3
05	ci	10.1	21.4	250	18	0
05	nb	10.3	21.5	200	5	3
05	os	9.8	22.0	150	5	2
05	rd	9.3	21.7	200	4	11
	Mean	10.0	21.6	200	7	4
12	ad	9.6	18.2	250	2	0
12	ci	9.6	18.4	250	4	0
12	fb	9.8	17.9	150	2	2
12	nb	9.0	19.0	150	2	4
12	os	8.7	20.0	300	1	2
12	rd	9.4	19.0	200	2	3
	Mean	9.3	18.8	217	2	2

Table 10.—Continued.

Date	Site	Water temperature (°C)	Salinity (‰)	Secchi depth (cm)	Wave height (cm)	Current (cm/s)
		Environmental variables				
		Gastineau Channel				
April						
17	cb	5.5	29.8	250	3	2
17	lm	4.9	29.7	500	9	7
17	ls	4.6	20.9	450	2	3
17	rb	5.0	30.7	500	4	2
17	sb	4.8	29.1	400	5	6
17	sc	5.5	27.7	300	2	3
	Mean	5.0	28.0	400	4	4
23	cb	7.2	26.0	150	2	2
23	lm	8.1	25.2	250	5	10
23	ls	7.6	25.9	250	5	0
23	rb	6.5	26.6	100	3	2
23	lb	7.5	26.5	100	5	7
23	sc	7.5	25.7	200	2	2
	Mean	7.4	26.0	175	4	4
30	cb	6.1	25.9	150	2	3
30	lm	6.3	26.2	150	4	3
30	ls	5.8	23.4	150	3	2
30	rb	5.9	26.4	200	0	3
30	sb	6.1	25.7	200	1	2
30	sc	5.8	26.2	200	1	15
	Mean	6.0	25.6	175	2	5
May						
07	cb	9.9	18.9	250	3	2
07	lm	11.0	22.2	200	4	5
07	ls	8.9	22.3	150	4	3
07	rb	8.9	20.5	150	7	8
07	sb	11.9	19.0	200	9	6
07	sc	9.7	22.3	150	1	5
	Mean	10.0	20.9	183	5	5
14	cb	7.6	17.7	200	0	3
14	lm	7.6	18.7	150	2	17
14	ls	7.5	18.2	100	0	5
14	rb	7.9	18.6	150	1	2
14	sb	7.8	17.9	100	6	4
14	sc	7.4	17.7	150	0	14
	Mean	7.6	18.1	142	2	8

Table 10.—Continued.

Date	Site	Environmental variables: Water temperature (°C)	Salinity (‰)	Secchi depth (cm)	Wave height (cm)	Current (cm/s)
May						
21	cb	9.4	16.6	—	4	8
21	lm	9.0	16.7	150	4	2
21	ls	9.8	13.6	200	5	4
21	rb	9.2	17.0	100	3	6
21	sb	9.2	15.6	200	5	3
21	sc	9.3	12.8	200	9	4
	Mean	9.3	15.4	170	5	4
29	cb	8.7	18.8	150	5	4
29	lm	8.3	15.0	150	6	4
29	ls	8.8	13.9	150	3	4
29	rb	8.7	15.2	150	6	1
29	sb	8.2	17.0	150	4	0
29	sc	8.9	14.8	150	2	0
	Mean	8.6	15.8	150	4	2
June						
04	cb	9.6	16.6	200	16	2
04	lm	9.6	15.5	200	8	7
04	ls	10.2	10.8	100	18	3
04	rb	8.3	20.8	300	15	4
04	sb	9.1	15.9	200	9	3
04	sc	10.1	15.7	150	5	4
	Mean	9.5	15.9	192	12	4
11	cb	7.5	17.1	150	1	—
11	lm	8.0	18.0	200	1	—
11	ls	8.3	16.6	150	2	—
11	rb	7.7	14.5	100	2	—
11	sb	7.7	16.7	200	4	—
11	sc	8.0	16.7	150	1	—
	Mean	7.9	16.6	158	2	—

FIGURES

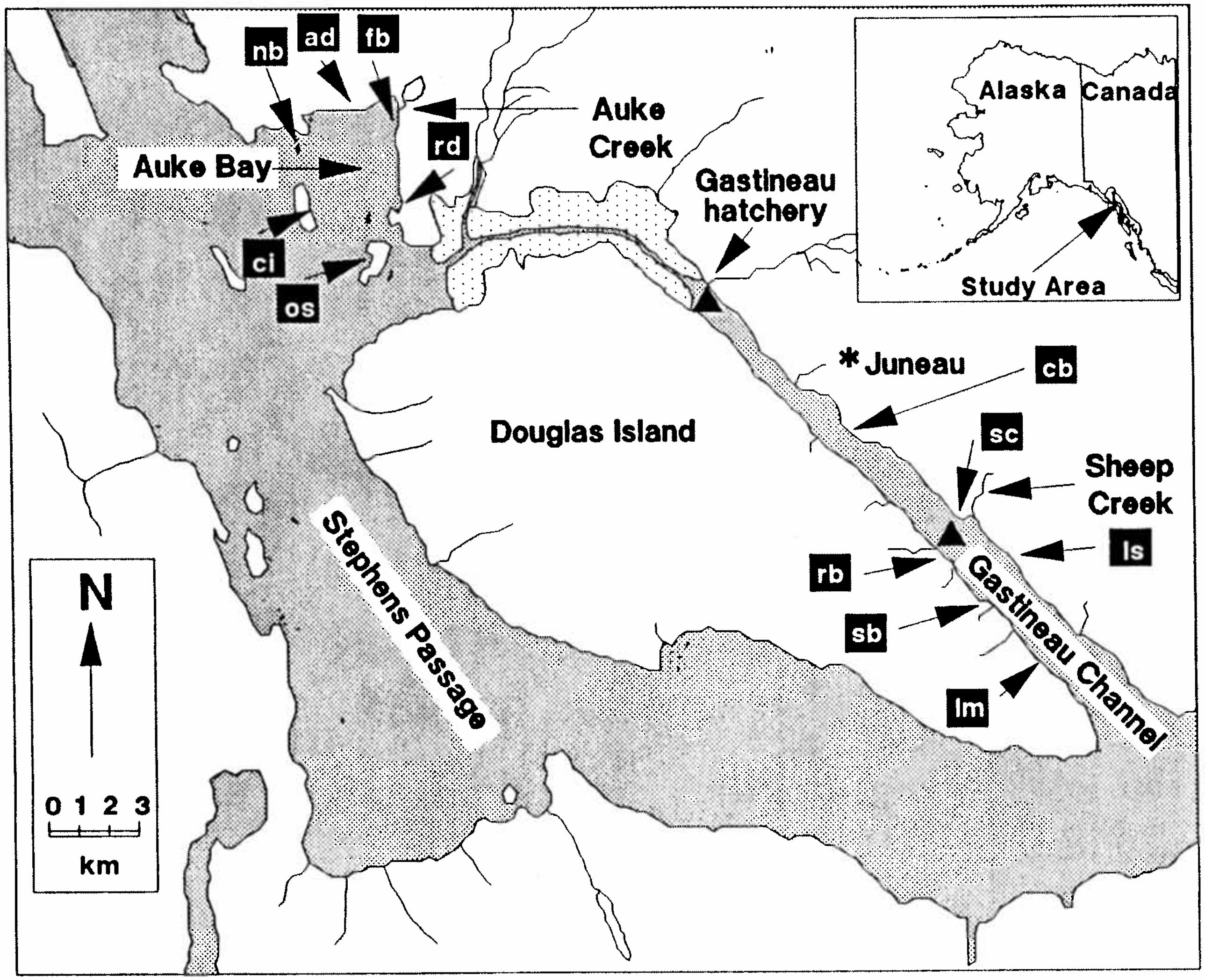

Figure 1.—Beach seining sites (■) and hatchery release sites (▲) in Auke Bay and Gastineau Channel. Auke Bay sites were Auke Nu Delta (ad), Coghlan Island (ci), Fred's Beach (fb), Nerka Beach (nb), Old Spuhn (os), and Reischel's Dock (rd). Gastineau Channel sites were Cross Bay Creek (cb), Lucky Me (lm), Little Sheep (ls), Ready Bullion (rb), Stump Beach (sb), and Sheep Creek (sc).

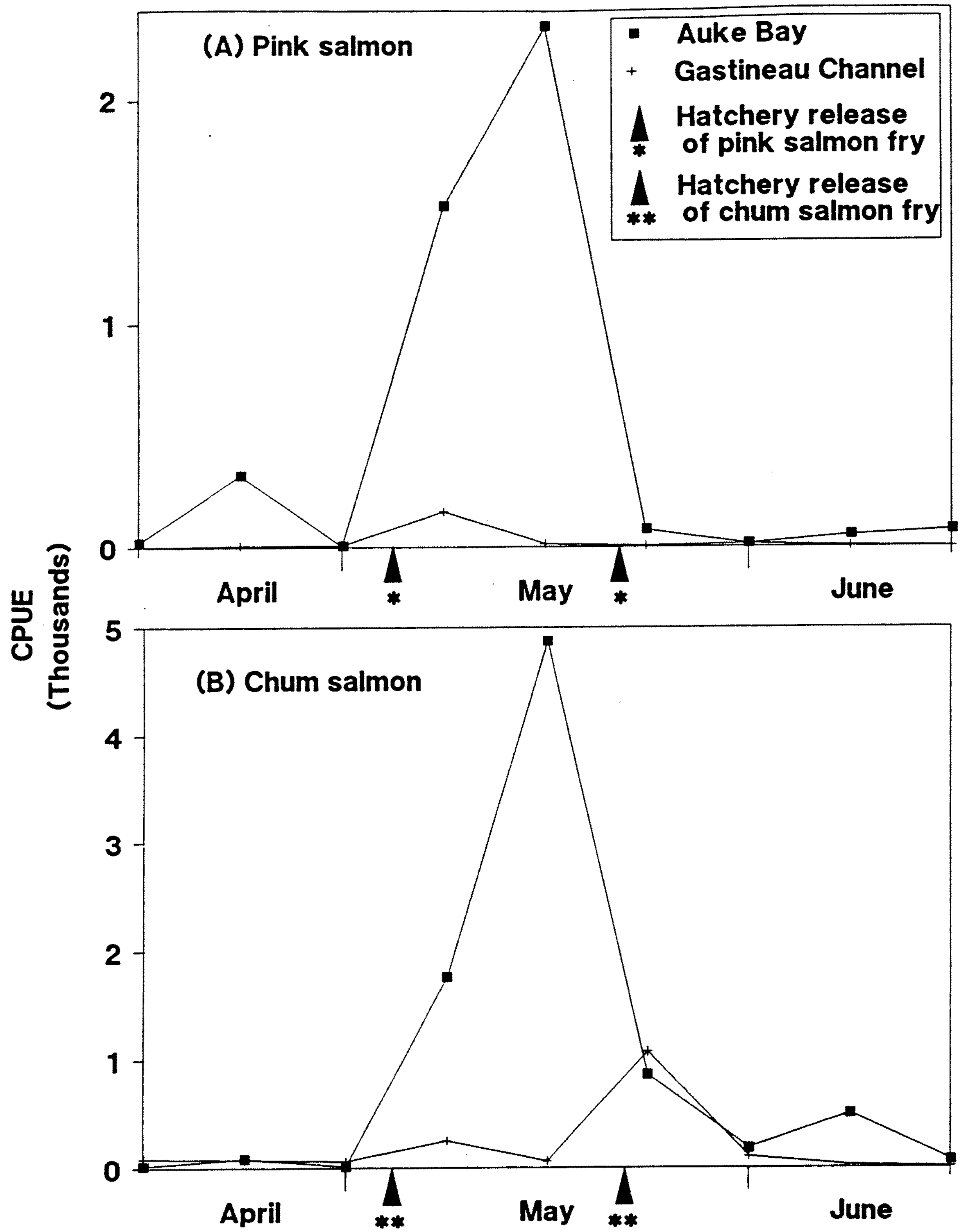

Figure 2.—CPUE of pink salmon and chum salmon in Auke Bay and Gastineau Channel, April–June 1991.

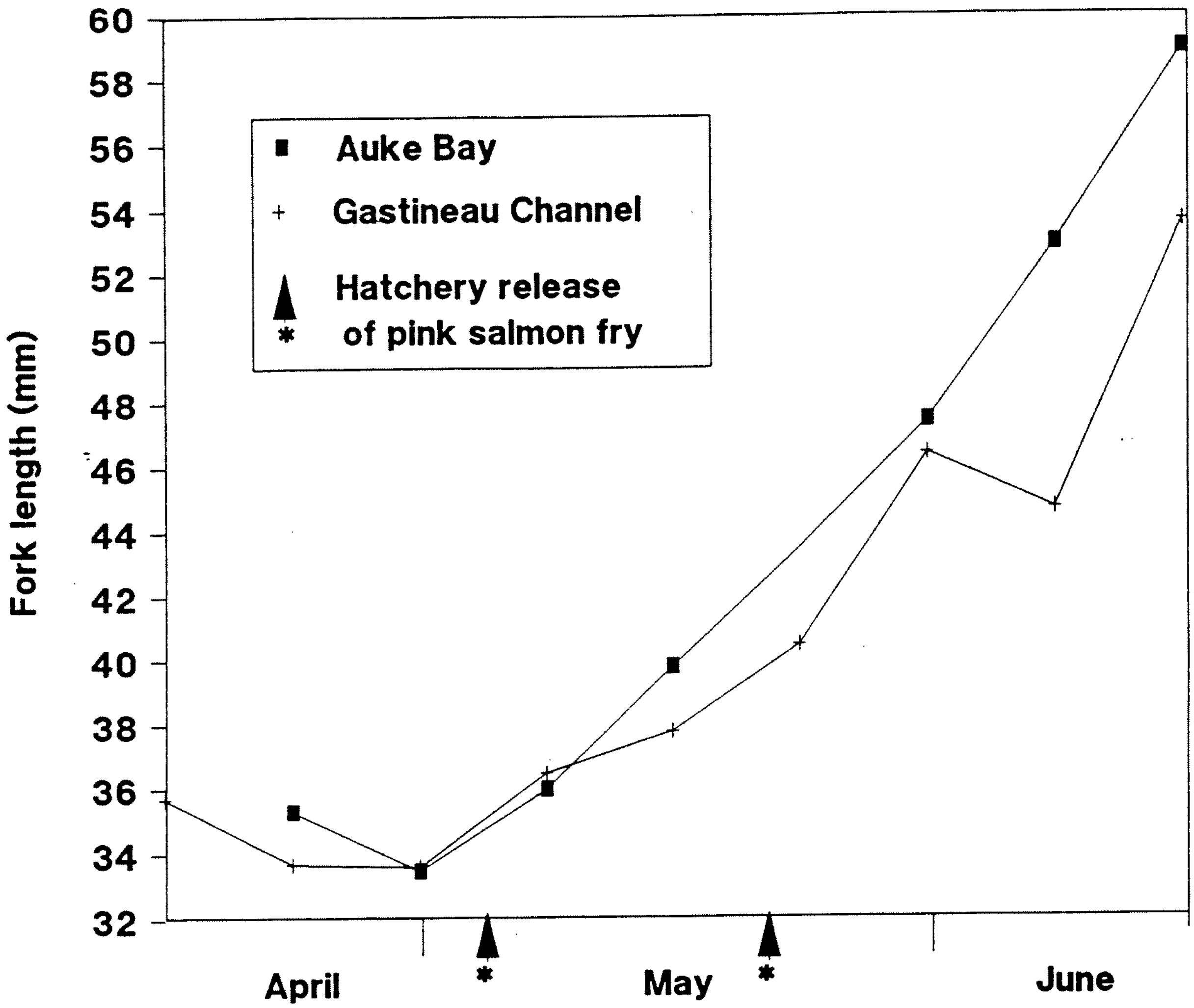

Figure 3.—Mean fork length of pink salmon in Auke Bay and Gastineau Channel, April–June 1991.

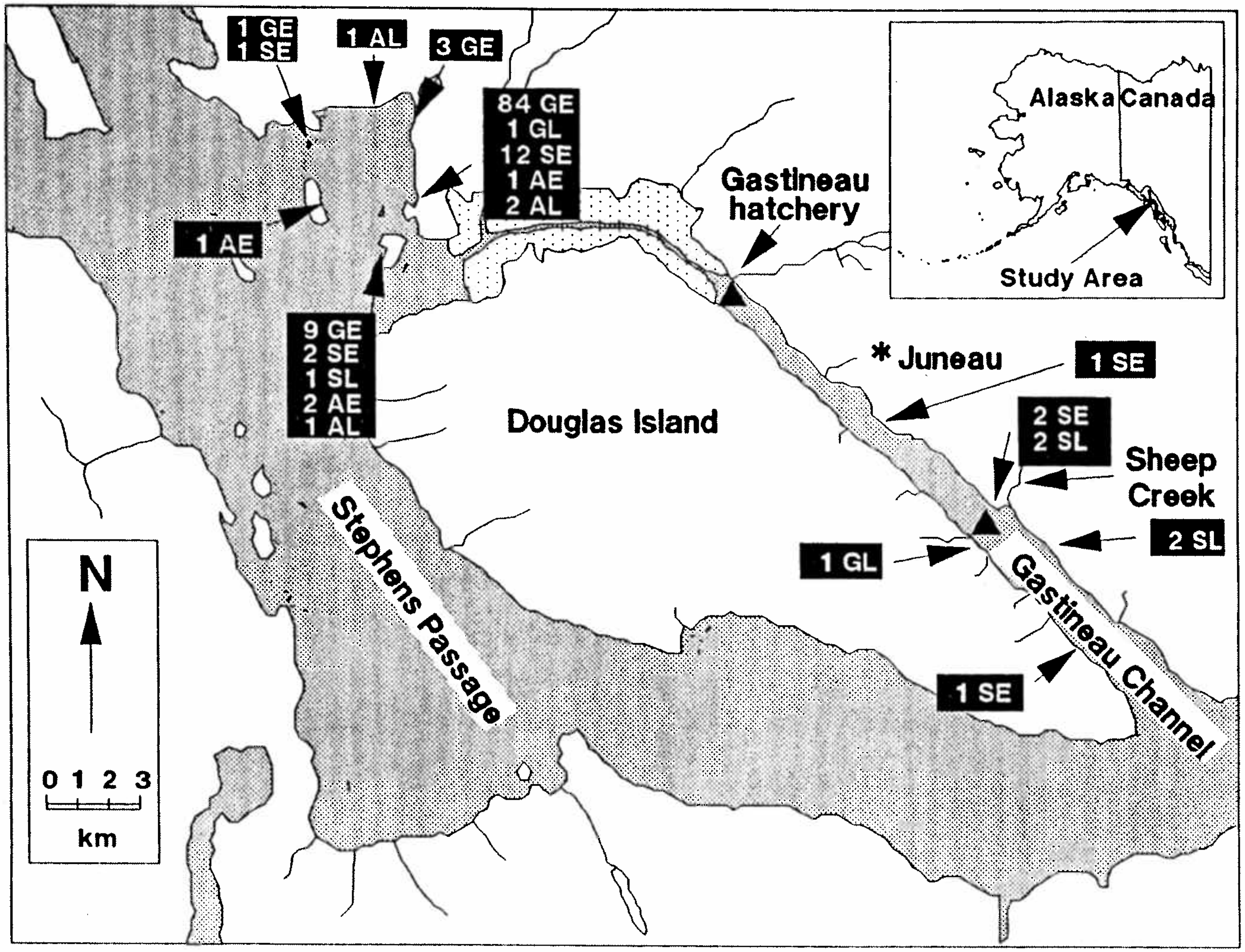

Figure 4.—Origin of coded-wire-tagged pink and chum salmon recovered in Auke Bay and Gastineau Channel, April–June 1991. Codes for tags are G (Gastineau Hatchery), S (Sheep Creek), A (Amalga Harbor), E (early chum salmon release), and L (late chum salmon releases). Hatchery release sites are marked ▲.

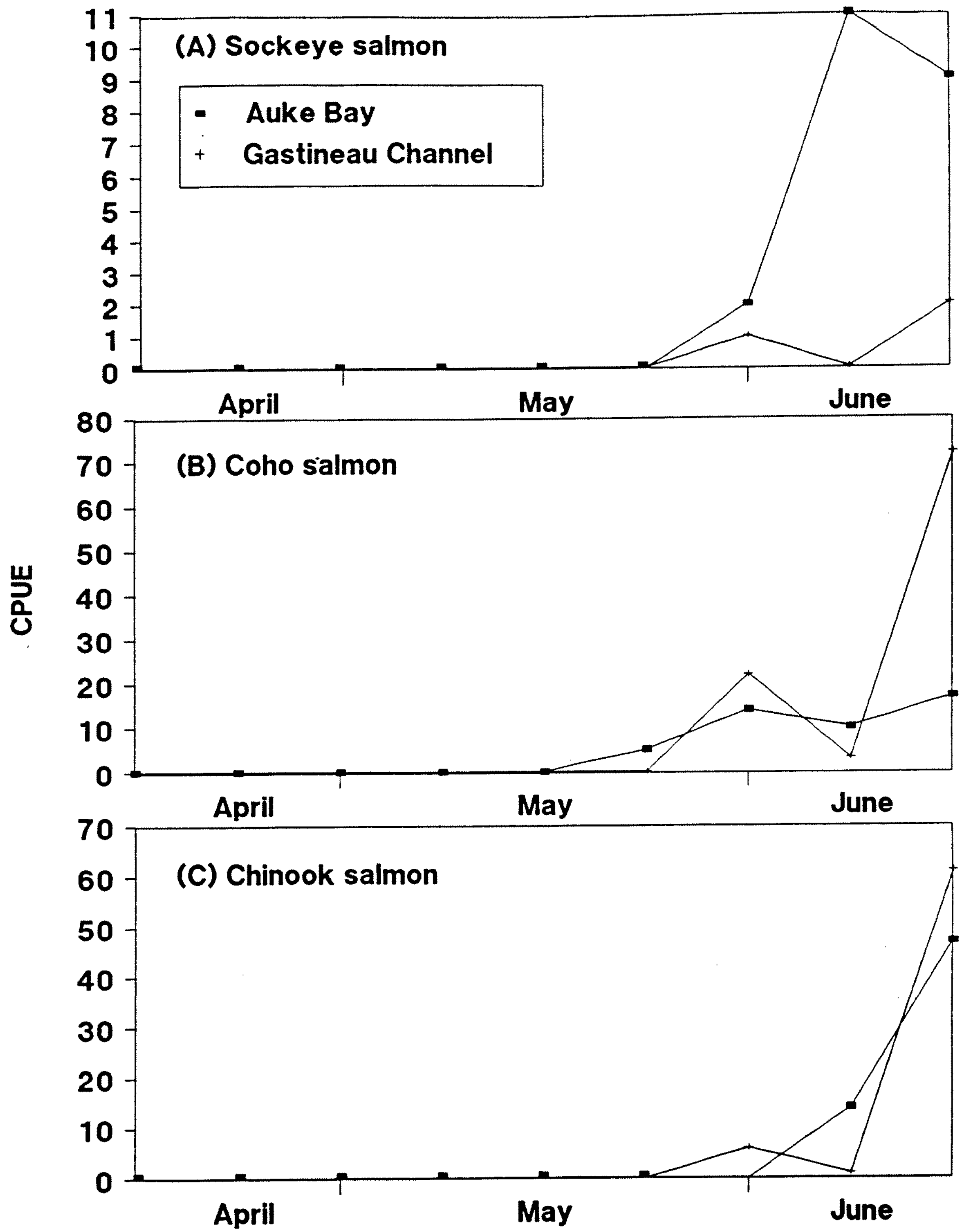

Figure 5.—CPUE of sockeye salmon, coho salmon, and chinook salmon in Auke Bay and Gastineau Channel, April–June 1991.

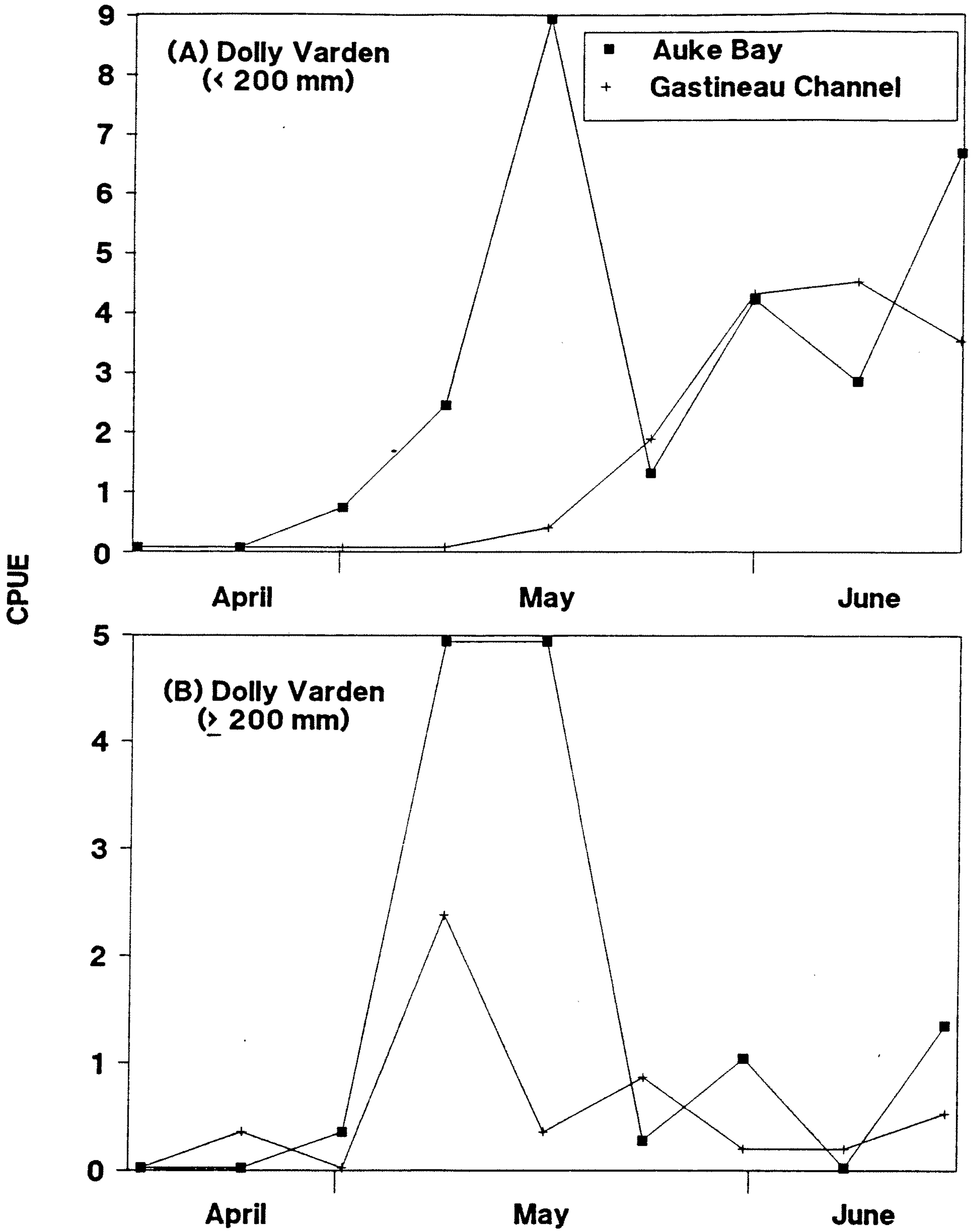

Figure 6.—CPUE of Dolly Varden <200 mm FL and ≥200 mm FL in Auke Bay and Gastineau Channel, April–June 1991.

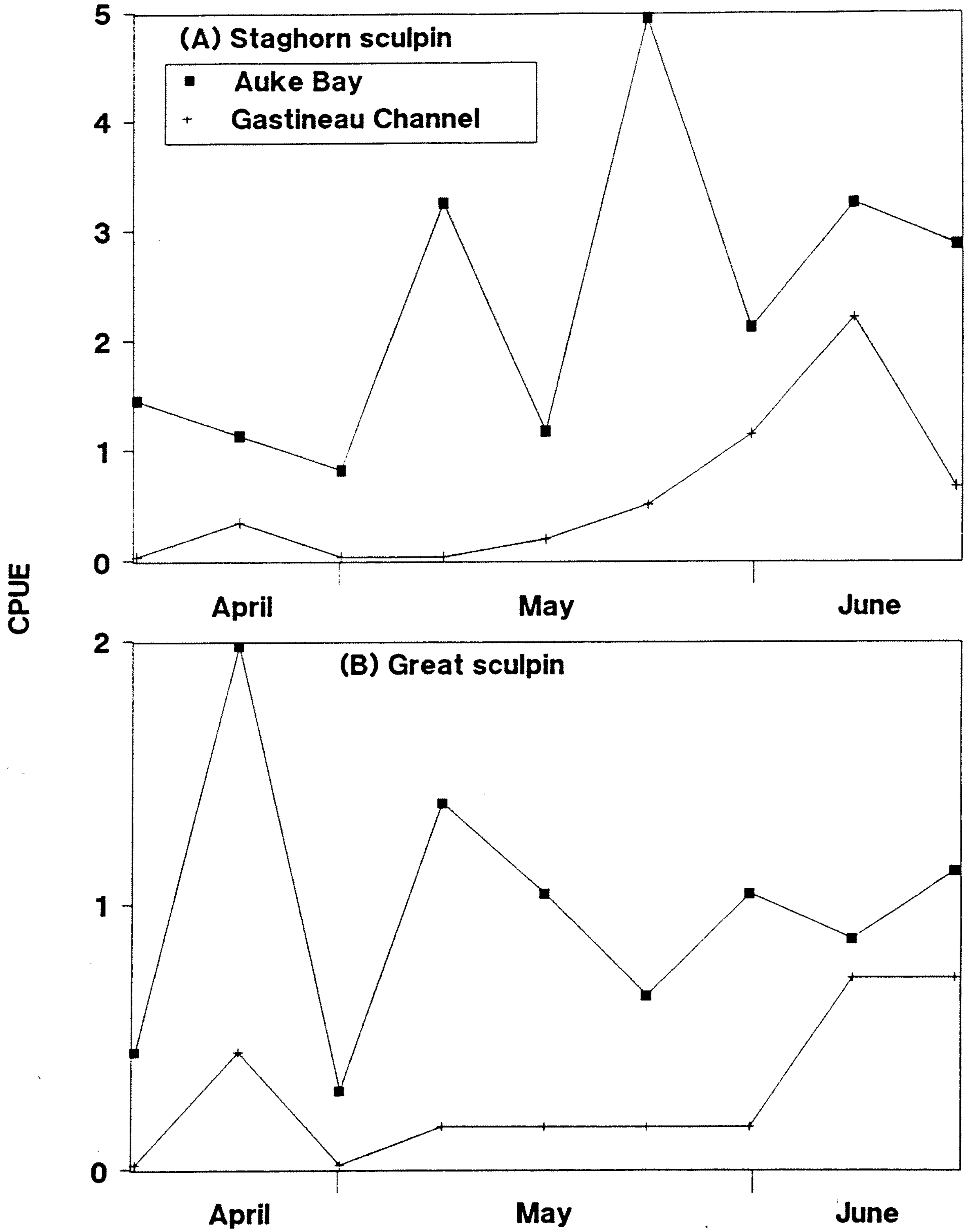

Figure 7.—CPUE of Pacific staghorn sculpins and great sculpins in Auke Bay and Gastineau Channel, April–June 1991.

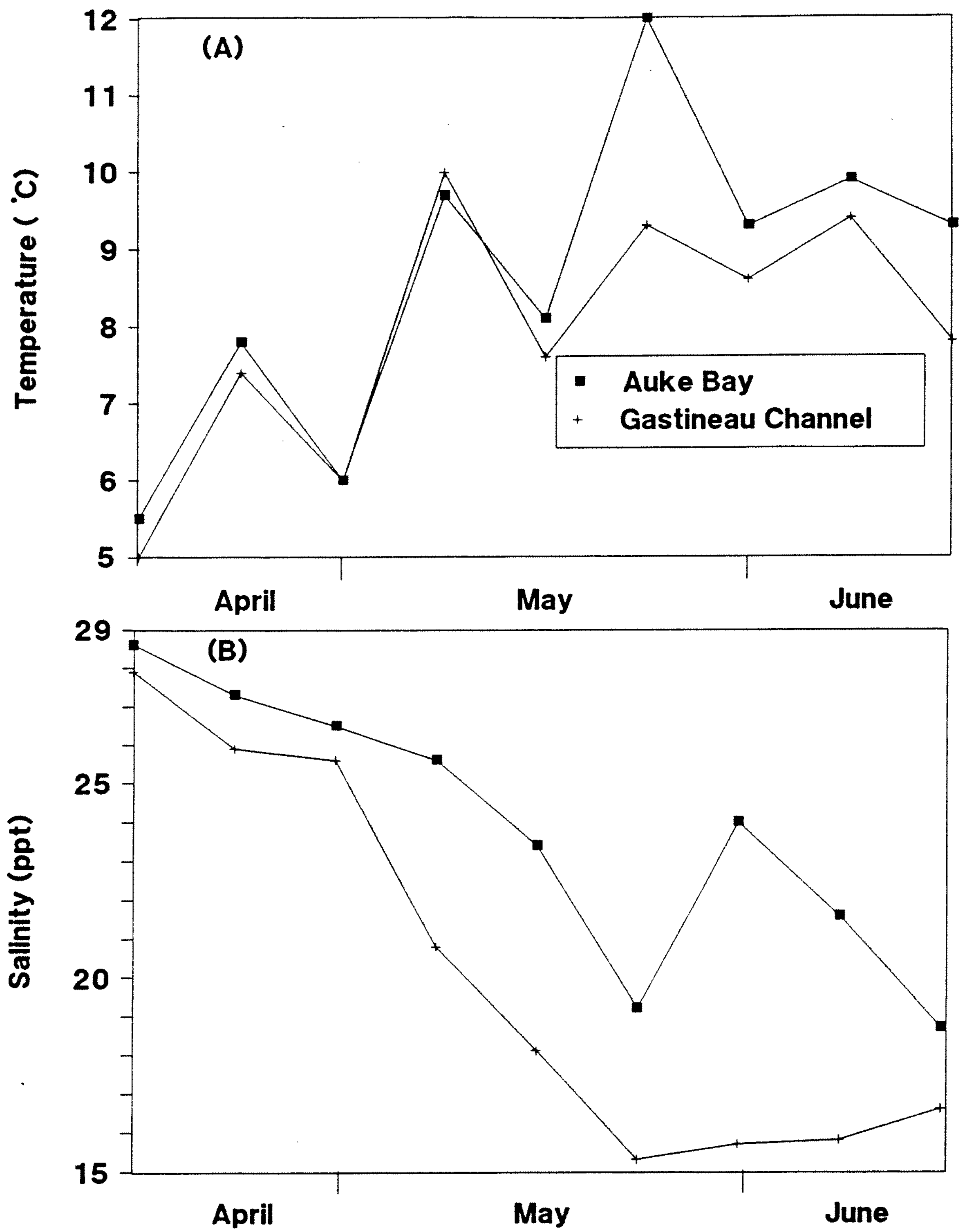

Figure 8.—Water temperature and salinity in Auke Bay and Gastineau Channel, April–June 1991.

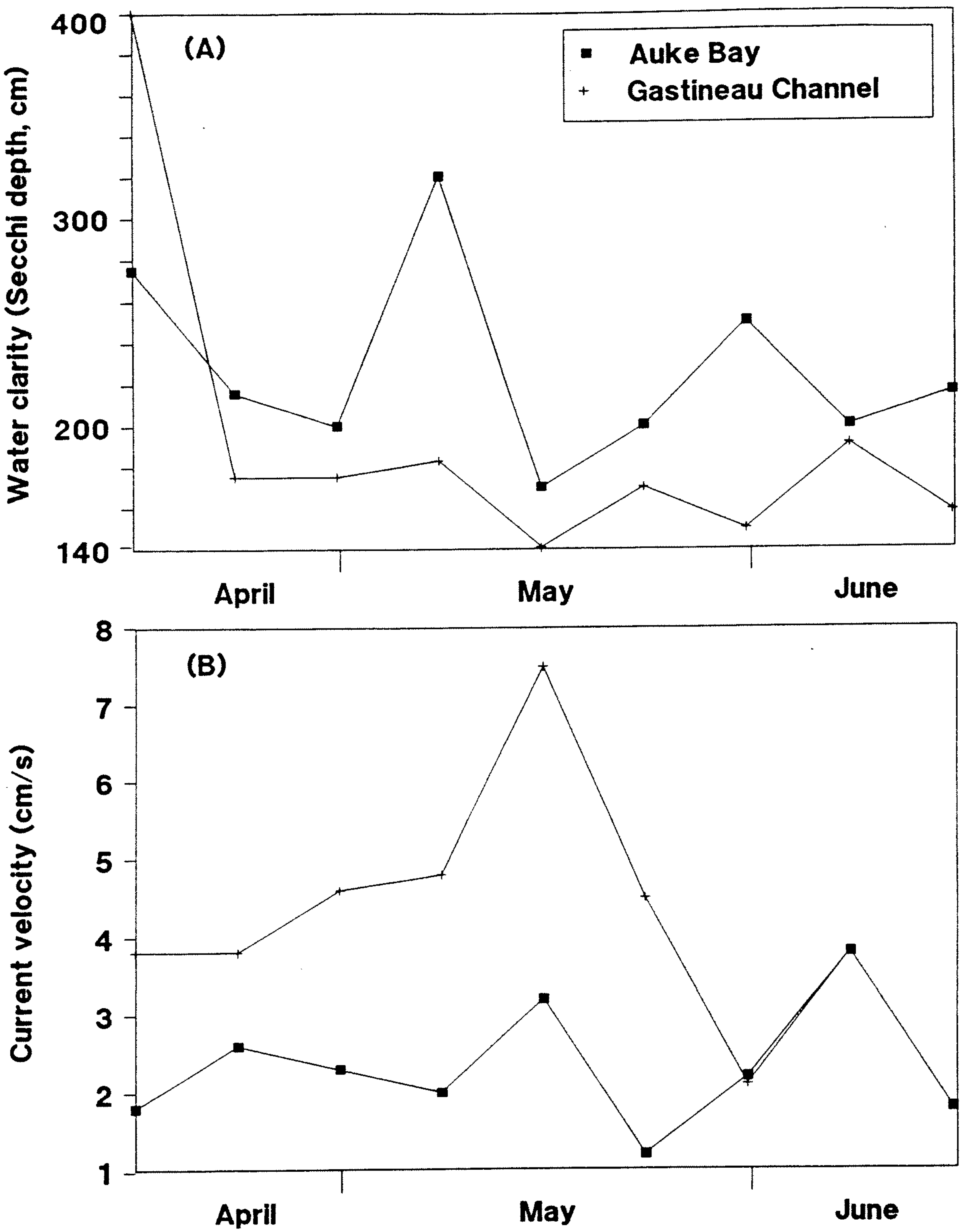

Figure 9.—Water clarity (Secchi disc depth) and current in Auke Bay and Gastineau Channel, April–June 1991.