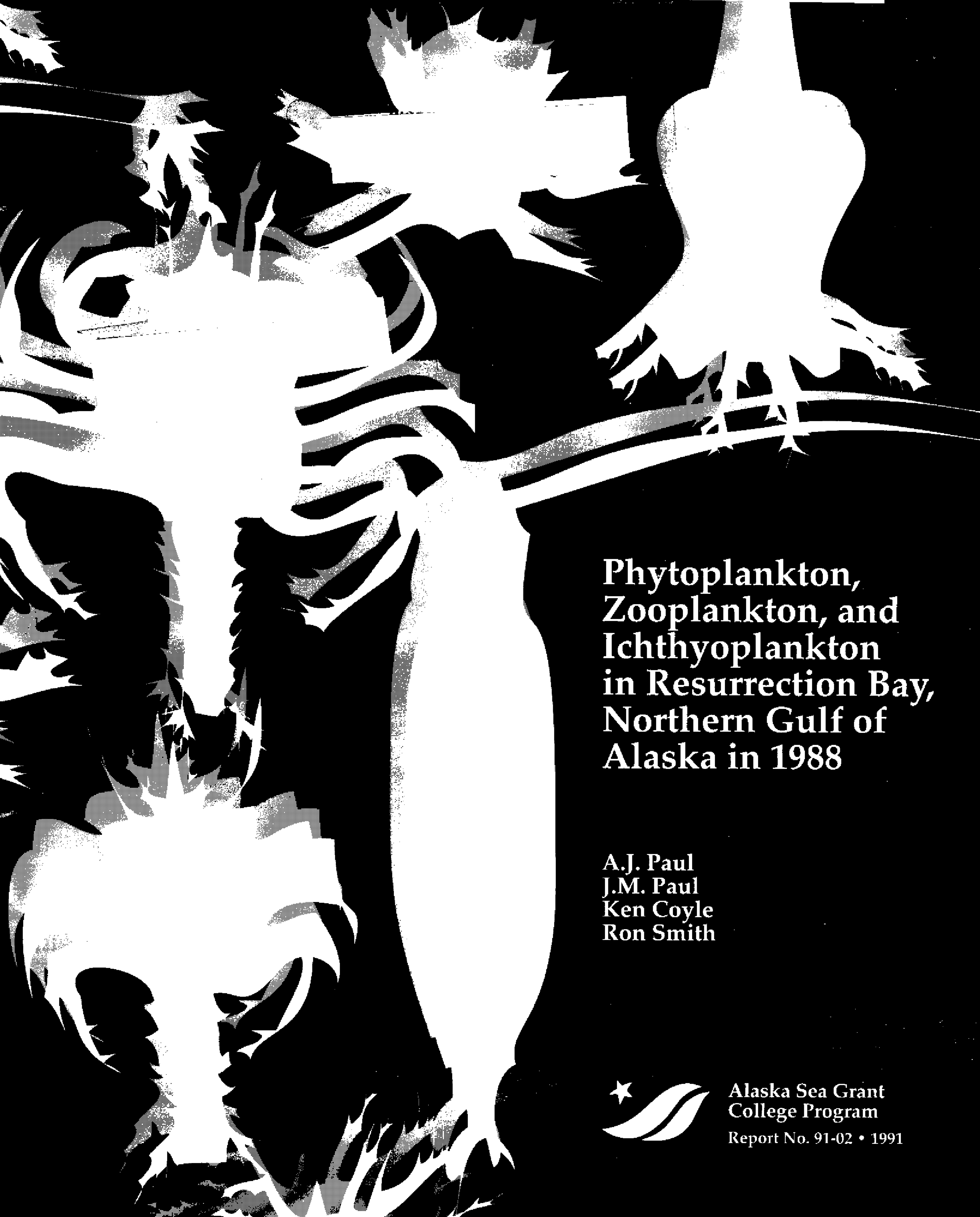

Phytoplankton, Zooplankton, and Ichthyoplankton in Resurrection Bay, Northern Gulf of Alaska in 1988

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INTRODUCTION

This report provides information on phytoplankton, zooplankton, decapod larvae, and ichthyoplankton in the Resurrection Bay fjord at the head of the "Seward line." The Seward line is a series of Institute of Marine Science, University of Alaska Fairbanks oceanography stations originating in Seward, Alaska, and extending into the Gulf of Alaska to Middleton Island. It is the only area in Alaska where physical oceanographic measurements are made on a regular basis (Xiong and Royer 1984, Royer 1989).

While a good physical oceanographic data base exists for the Seward line, very little is known about the area's biology. No previous reports describe the plankton taxa along the Seward line. Nor has primary production in the embayments of the northern Gulf of Alaska been well described. The limited work done on primary production in Resurrection Bay is reported in Heggie et al. (1977).

This report is based on a preliminary plankton survey of the Resurrection Bay fjord funded by the Alaska Sea Grant College Program to provide an information base for planning fisheries oceanography investigations.

METHODS

STUDY SITE

All work was done at the head of the University of Alaska oceanographic station line in Resurrection Bay. Three stations, R1 (depth 69 m), R2.5 (depth 285 m), and R4 (depth 225 m) were sampled (Fig. 1, p. 8). The Gulf of Alaska lies just beyond station R4. Information on the study site is in Heggie et al. (1977).

PHYTOPLANKTON

Phytoplankton samples were collected weekly at 10 m depth with water bottles at stations R1, R2.5, and R4 during spring and early summer of 1988. Cell counts were done in triplicate using the inverted microscope method (Lund et al. 1958).

ZOOPLANKTON

Copepod nauplii were sampled with a separate 10 liter water bottle taken at 10 m depth at stations R1, R2.5, and R4 during spring and early summer of 1988. Each week a single bottle cast was taken at the three stations. Water from the bottle was passed through a 64 µm bag net and the concentrated sample preserved for microscopic analyses.

Because fish larvae may select specific size nauplii, the nauplii were measured with an ocular micrometer and divided into three groups: less than 150 µm, 150–350 µm, and larger than 350 µm body length. Pollock larvae, for example, typically eat 150–350 µm nauplii when they first start to feed (Dagg et al. 1984, Sterritt 1989). The 10 m depth was selected because pollock larvae are often found there (Dagg et al. 1984, Pritchett and Haldorson 1989).

Larger zooplankton were collected with a 1 m^2 NIO net (National Institute of Oceanography) (with flow meter) towed double obliquely from 25 m to the surface. A single tow was collected for each sample. Mesh size was 505 µm. Standard methods based on flow meter data were used to estimate the amount of water sampled. The samples were preserved in 10% formalin.

Euphausiid larvae were collected with a

0.5 m 165 µm mesh ring net towed vertically from 30 m to the surface at station R1. Decapod larvae were counted from all the NIO net samples from all three of the stations. They were removed from weekly collections before samples were split for zooplankton analysis. Pandalid larvae and one taxon of oregonid larvae were staged. Biomass estimates for decapod larvae were not made.

Zooplankton taxa analysis was done only for selected dates from samples collected at station R4. The NIO samples were split with a Folsom splitter to reduce the sample volume to a manageable level. All animals were identified to the most specific possible taxonomic category or stage, and blotted wet weights were measured with an electrobalance.

Since the objective of this report primarily is to describe the taxa in the plankton community, not much effort was directed to replication of samples. Thus the data should be considered only as relative abundances, and no confidence limits are placed on the biomass or population estimates.

FISH LARVAE

Fish larvae were also counted from the NIO net samples. They were removed from samples taken at all three stations, but only every other week. The larvae were taken out of the collection before samples were split for counting zooplankton. Fish larvae were enumerated and identified but not measured.

RESULTS AND DISCUSSION

PHYTOPLANKTON

A phytoplankton taxa list and estimates of relative cell abundance for 31 March through mid-July 1988 are in Table 1 (p. 13). The phytoplankton taxa are similar to those listed in the few existing reports for Gulf of Alaska embayments (Horner et al. 1973, Laws et al. 1988).

Diatoms usually predominate in the early spring, with the genera *Chaetoceros*, *Cylindrotheca*, and occasionally *Thalassiosira* dominating the community in numbers. By June pennate diatoms and flagellates are the most abundant cells. Phytoplankton cell counts are similar to Prince William Sound (Horner et al. 1973), but lower than Auke Bay near Juneau (Laws et al. 1988) and Kachemak Bay in Cook Inlet (Larrance and Chester 1979). The differences in cell abundance may be related to geographical variations in grazing pressure.

ZOOPLANKTON

Nauplii

Copepod nauplii (150–350 µm) were present at less than 10 per liter during the first three weeks of April (Table 2, p. 14). Nauplii of this size were in concentrations above 20 per liter on all sampling dates after April, and exceeded 100 per liter in mid-May. Nauplii less than 150 µm, and over 350 µm length, were typically less than 10 per liter.

Our sampling was restricted to the 10 m depth so it is probable that maximum densities of nauplii were often missed. However, the general population trends were similar to those observed in other areas (see Paul et al. 1991 for review) with low abundances of nauplii in early spring followed by increasing numbers as the spring bloom progressed. In general, copepod nauplii abundances in Resurrection Bay were similar to other reported values of 1–30 per liter for Auke Bay in southeastern Alaska (Haldorson et al. 1989) and the southeastern Bering Sea (Dagg et al. 1984).

Calanoid Copepods

Minimum zooplankton biomass (station R4) was about 0.1 g per m^3 in early April (Fig. 2, p. 9). By late April the biomass had begun to increase and had reached 2.2 g per m^3 by early June. During the entire sampling period the zooplankton biomass was dominated by calanoid copepods (Figs. 3, 4; p. 9, 10). The major copepod taxa contributing to the biomass were *Neocalanus plumchrus*, *Calanus marshallae*, and *Pseudocalanus* spp. (Tables 3, 4; p. 15, 16; Fig. 4).

Neocalanus plumchrus

Neocalanus plumchrus (Figs. 4, 5; p. 10) responded to spring conditions early in the sampling, with substantial biomass increases by the second half of April. *N. plumchrus* biomass continued to increase until about mid-May but by the end of June its biomass was negligible.

The presence of *N. plumchrus* indicates cross shelf transport of oceanic plankton into the fjord. However, some of their nauplii and copepodids may have been produced in Resurrection Bay where water is deep enough for *N. plumchrus* to overwinter.

Based on minor morphological distinctions and some life history differences, *N. plumchrus* has been divided into two species, the original *N. plumchrus* and the new species *N. flemingeri* (Miller 1988). Since we did not distinguish between the two during analysis, *N. plumchrus* may include both species, or belong with *N. flemingeri*.

Calanus marshallae

The biomass of *Calanus marshallae* (Fig. 4) began to increase by mid-May and reached maximum values of about 0.6 g per m^3 by the end of May, after which it also declined to negligible amounts by the end of June. Stage 5 and adults were most abundant at the end of May and early June (Fig. 6, p. 11).

Pseudocalanus

Pseudocalanus spp. (Figs. 7, 8; p. 11, 12) biomass increased throughout May, reaching maximum value of 1.4 g per m^3 by early June. Relative abundance of some different stages are plotted in Figure 8. The percentage frequency of cope-podid stages 1 and 3 and adults was calculated for *Pseudocalanus* spp. to estimate the generation time and life history stages of this species.

The high populations of *Pseudocalanus* spp. stage 1 copepodids in late March suggest that the overwintering females released eggs in late February or early March. The cohort matured to copepodid stage 1 by late March, to stage 3 by mid-April, and adults predominated by late April and early May.

A second major cohort of stage 1 copepodids entered the population in late May and reached adulthood in early June. Thus, the large increase in *Pseudocalanus* spp. biomass observed in late May and early June may have been partly due to the maturation of stage 1 copepodids into later developmental stages. The abundance of adult female *Pseudocalanus* spp. prior to the spring bloom has been shown to be one of the most important factors in determining subsequent nauplii availability for larval fish in southeastern Alaska (Paul et al. 1990).

Trophic Phasing of Copepods

Our data suggest that a trophic phasing of the various copepod taxa provided constant grazing pressure on the phytoplankton populations during spring. Decreases in *N. plumchrus* populations were followed by increases in *C. marshallae* populations which were followed by increases in *Pseudocalanus* spp. populations. The increase in *N. plumchrus* populations in April resulted from increasing densities of stage 4 and 5 copepods (Fig. 5, p. 10).

The increase in density of stage 5 copepods in May follows the earlier stage 3 and 4 copepodids. Decreases in *N. plumchrus* copepodid stage 5 populations during late May and early June is probably due to the ontogenetic vertical migration into deep water that this species undergoes near the end of spring.

Calanus marshallae stage 3 densities were low throughout most of the season (Fig. 6, p. 11), probably due to escapement by the stage 3 copepodids through the 505 µm mesh net. High concentrations of stage 4 and 5 copepodids occurred in late May and early June. Few adults were present in the samples and their absence may be due to diurnal vertical migration of the adult stages. Night sampling might verify this possibility.

Total Zooplankton Biomass

Total zooplankton wet weight biomass at station R4 was about 0.1 to 0.2 g per m^3 in April but climbed to about 2.2 g per m^3 by early June. Wet weight biomass in Auke Bay, southeastern Alaska, was 0.1 to 0.8 g per m^3 in April and reached values of almost 2.0 g per m^3 by late May and June (Coyle et al. 1990).

The Auke Bay samples were collected at night with similar NIO net tows taken from the surface to immediately above bottom (≈ 50 m depth). This methodology resulted in higher biomass values for certain taxa than the methods used for the Resurrection Bay zooplankton survey.

Since the R4 samples were collected during the day and the nets were deployed only to 25 m depth, the zooplankton biomass estimates probably represent a minimal value. Euphausiids and vertically migrating copepods, which may be major components of zooplankton biomass, were absent from the samples because of limitations of the sampling methods. Night sampling or much deeper sample depth would be needed to capture these organisms.

In Resurrection Bay copepod biomass in the upper 25 m during the day reached 2.0 g per m^3 by late May, indicating that its total zooplankton biomass is far greater than that of the shallow environment of Auke Bay.

The biomass of *Pseudocalanus* spp. in Resurrection Bay reached 1.4 g per m^3 in late May and early June. Comparable zooplankton abundance estimates are available for one other Gulf of Alaska embayment, Auke Bay. Copepod wet weight biomass reached only about 0.5 g per m^3 there in 1988 (Coyle et al. 1990). The remaining biomass consisted primarily of euphausiids and meroplankton.

Pseudocalanus spp. biomass in Auke Bay did not exceed 0.5 g per m^3 from April to June (Coyle et al. 1990). Further measurements are needed to determine if the biomass of Resurrection Bay copepods is consistently higher than Auke Bay.

The biomass of *Neocalanus plumchrus*, *N. cristatus*, *Metridia pacifica*, and *Eucalanus bungii bungii* reached 9 to 10 grams carbon per m^2 on the outer shelf and continental slope of the southeast Bering Sea (Vidal and Smith 1986). Since the samples were collected to 120 m depth, the wet weight biomass of the outer Bering Sea shelf copepod populations can be estimated as follows (Omori 1969, 1970):

Number per m^3 = (Number per m^2) ÷ 120
Dry weight = (Carbon weight) ÷ 0.5
Wet weight = (Dry weight) ÷ 0.15

With the above assumptions, the wet weight biomass of the Bering Sea shelf break community would be about 1–1.2 g per m^3. Apparently, Vidal and Smith (1986) did not correct for weight loss due to formalin preservation. If weight loss due to formalin preservation is assumed to be about 50% (Omori 1970), the wet weight biomass of Bering Sea shelf break copepods would be about 2 g per m^3, similar to values obtained for the daytime surface copepod community at station R4.

Euphausiids

The shallow daytime sampling methods used to collect plankton are poorly suited to capturing euphausiids. However, euphausiids are known to be abundant in Resurrection Bay because every spring windrows of *Thysanoessa spinifera* wash ashore after their post-spawning death (personal observation).

The vertical hauls at station R1 provided some insight into the relative abundance of euphausiid larvae (Table 5, p. 17). Euphausiid eggs and nauplii were most abundant during early May following the peak of the spring diatom bloom. The results of our limited observations suggest the Resurrection Bay area would be ideal for a euphausiid survival experiment.

The observations of zooplankton abundance show that the Resurrection Bay area has a rich plankton community. However, deeper sampling and night sampling should be carried out in order to more thoroughly describe the zooplankton community.

Decapod Larvae

Tanner crab (*Chionoecetes bairdi*) first zoeae abundances were 180 to 270 per 100 m^3 on 11 May (Table 6, p. 17). But the megalopa stages of Majidae larvae consisted mainly of *Oregonia* or *Hyas* rather than Tanner crab. In the southeastern Bering sea Incze et al. (1987) reported *C. bairdi* first zoeae at about 2,000 per 100 m^3. Thus over the shallow mid-shelf region of the southeastern Bering Sea, where the largest harvest of this species occurs, larvae are several times more abundant than in Resurrection Bay.

The predominant pandalid zoeae in the samples were *Pandalus borealis*, the northern shrimp (Table 7, p. 18). Stages 1 and 2 were predominant in numbers in April, and stages 3 and 4 in May. While stage 5 was present in the samples in late May and early June, their populations were low, suggesting high mortality, advection, or an ontogenetic migration below our sampling depth of the upper 25 m. Spot shrimp (*P. platyceros*) and sidestripe shrimp (*Pandalopsis dispar*) first zoeae had a much lower maximum abundance than did northern shrimp (Tables 8, 9; p. 19,20).

The other major decapod taxa in the samples included Brachyrhyncha, Hippolytidae, Crangonidae, and anomurans (Table 3, p. 15). The Brachyrhyncha include the Cancridae, Atelecyclidae, Xanthidae, and Pinnotheridae. The only commercially important crab in this group is *Cancer magister*, the Dungeness crab. The hippolytids and crangonids are noncommercial epibenthic and benthic shrimp families, common throughout Alaska. The anomurans include the hermit crabs and lithodids; the latter family includes king crab. Because king crab are seldom encountered by trawling in Resurrection Bay, the low number of king crab larvae was expected.

Phytoplankton species abundance is important in determining growth and survival of some decapod larvae (Paul et al. 1989, 1990). Phytoplankton cells seem to be in relatively low abundance in Resurrection Bay (Table 1, p. 13). But since the zoeae from several species survive in the fjord, some balance between grazing and zooplankton predation must provide them with adequate nutrition. Studies of decapod larvae survival in natural communities of the area would provide insight into the recruitment process.

FISH LARVAE

The most common fish larvae in the Resurrection Bay samples were pollock (*Theragra chalcogramma*), flathead sole (*Hippoglossoides elassodon*), herring (*Clupea harengus*), and sand lance (*Ammodytes hexapterus*).

Pollock (Table 10, p. 21) were most abundant at stations R4 and R2.5 during late April through mid-May. At 0.8 to 4.1 per m^3 they were several times more abundant than in the mid-shelf region of the southeastern Bering Sea (Dagg et al. 1984). Their abundance in Resurrection Bay is lower than peak abundances of pollock larvae in Shelikof Strait, but within the range of values observed (Kendall et al. 1987). Our observations, and those of Haldorson et al. (1989) suggest that many embayments along the northern Gulf of Alaska may serve as pollock nurseries.

Pollock first-feeding larvae eat copepod nauplii in the 150–350 µm length group (Paul 1983, Sterritt 1989). The April pollock larvae had to feed at much lower nauplii concentrations than did the May and June larvae (Table 2, p. 14). After 5 May, nauplii were 24–129 per liter. This is a relatively rich prey-field, especially compared to the southeastern Bering Sea where nauplii are generally present at less than 20 per liter (Dagg et al. 1984). Nauplii counts in Resurrection Bay are similar to Auke Bay in southeastern Alaska (Haldorson et al. 1989)

Herring larvae (Table 11, p. 21) were most abundant from mid-May through the end of June when the major cohort of copepod nauplii was present, peaking between 18 May and 1 June when the nauplii prey-fields were well developed (Table 2, p. 14). Based on metabolic needs, first-feeding herring larvae only require prey densities of 0.5 to 8 per liter to survive (Purcell and Grover 1990).

In the laboratory, herring larvae saturation feeding response occurs around 30 per liter (Munk and Kiorboe 1985). Thus between 18 May and 1 June, with nauplii between 34 and 140 per liter, competent larvae should have encountered adequate prey concentrations.

Sand lance larvae (Table 12, p. 21) were most abundant in the earliest samples, suggesting that their peak abundance may have been missed by not sampling early enough in the year. The time of hatching of sand lance is poorly known.

Flathead sole first appeared on 5 May and were most abundant in the first week of June. By mid-June they were no longer present in the samples (Table 13, p. 21).

Some larval fish, like *T. chalcogramma*, have better growth rates if they hatch when copepod nauplii are most abundant (Haldorson et al. 1989). Figure 9 (p. 12) illustrates the average abundance of larval fish and copepod nauplii for the three sampling stations combined. Pollock larvae were most abundant on 21 April, three weeks earlier than the greatest abundance of nauplii in mid-May. Pollock larvae were still present in the samples from mid-May into early June, indicating that some began feeding when their prey was most abundant.

Herring larvae were most abundant during the 18 May and June 1 samples when the major cohort of copepod nauplii was present. Flathead sole larvae were most abundant when nauplii exceeded 30 per liter. First-feeding flathead sole larvae are no longer prey limited around 15 per liter (Haldorson et al. 1989), so nauplii abundance should not limit their growth.

In 1988 the early walleye pollock cohort and the sand lance larvae were poorly matched in time to the spring peak of nauplii abundance, while the herring, flathead sole, and late hatching pollock larvae were well matched in time with their prey.

FUTURE STUDIES

The major objective of this survey was to identify organisms in the plankton community of Resurrection Bay abundant enough to be the focus for future fisheries oceanographic studies. Our preliminary plankton survey, in this glacially influenced fjord, found that larvae of walleye pollock (*Theragra chalcogramma*) and northern shrimp (*Pandalis borealis*) are likely candidates for future studies. Flathead sole and herring larvae are also numerous. The high abundance of sand lance larvae suggests that this is an important forage fish in the region. This species is important prey of a variety of predatory fish and seabirds. A study of its recruitment and population dynamics would make a valuable contribution to the understanding of the north Pacific ecosystem.

Examining processes that modify copepod nauplii production for larval fish prey in deep fjords would be useful, since most of this kind of work has been done in Alaska's shallow shelf areas. Likewise studies of coupling between primary production and grazing would be valuable, since most of the existing information on this topic is from Alaska's shallow shelf areas. Comparative studies that examine how northern shrimp larvae can survive in the phytoplankton-poor fjord and in phytoplankton-rich shallow bays like Auke Bay would also provide important insight into the recruitment process for decapods.

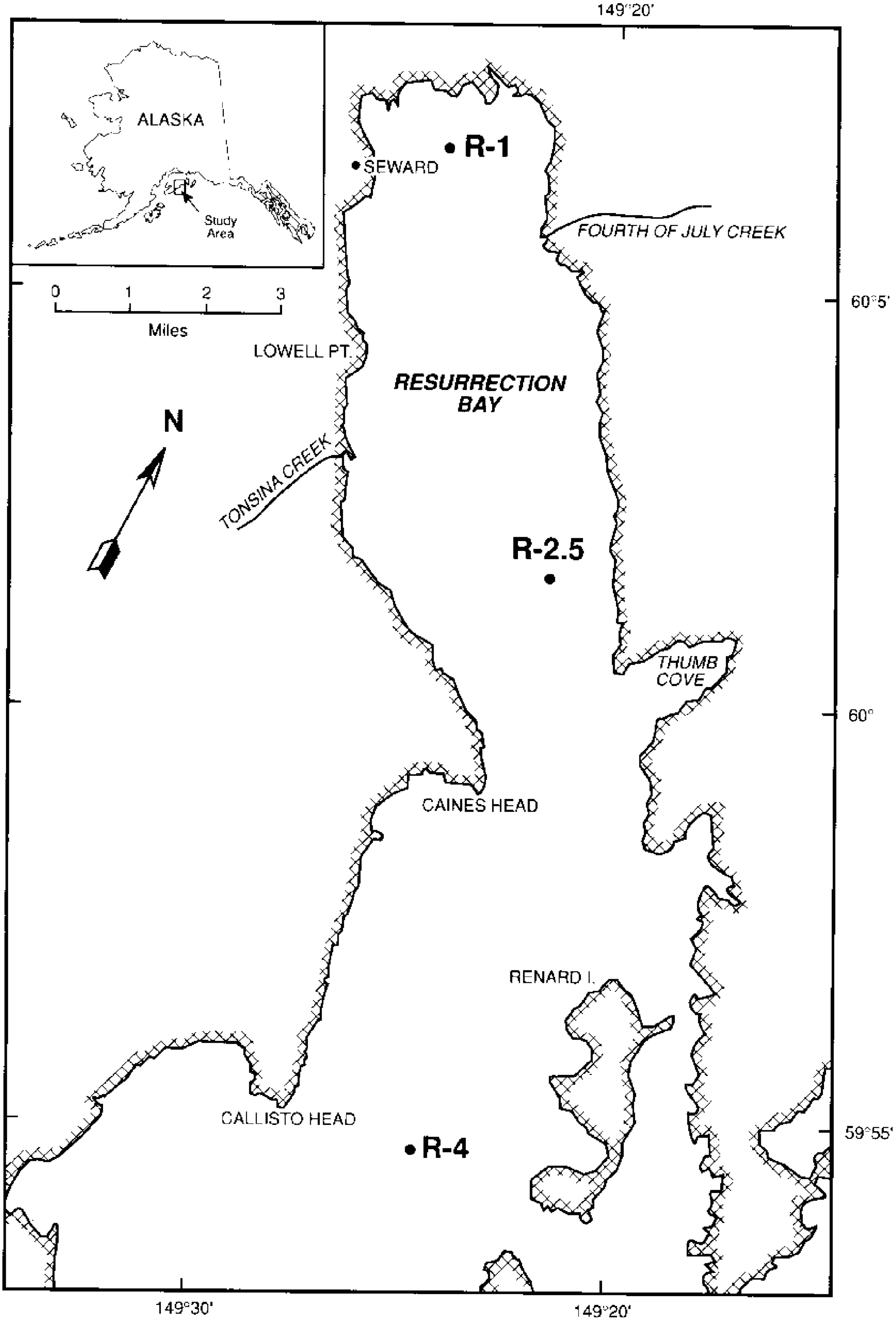

Figure 1. Map showing three stations sampled for plankton in Resurrection Bay, Alaska, spring 1988.

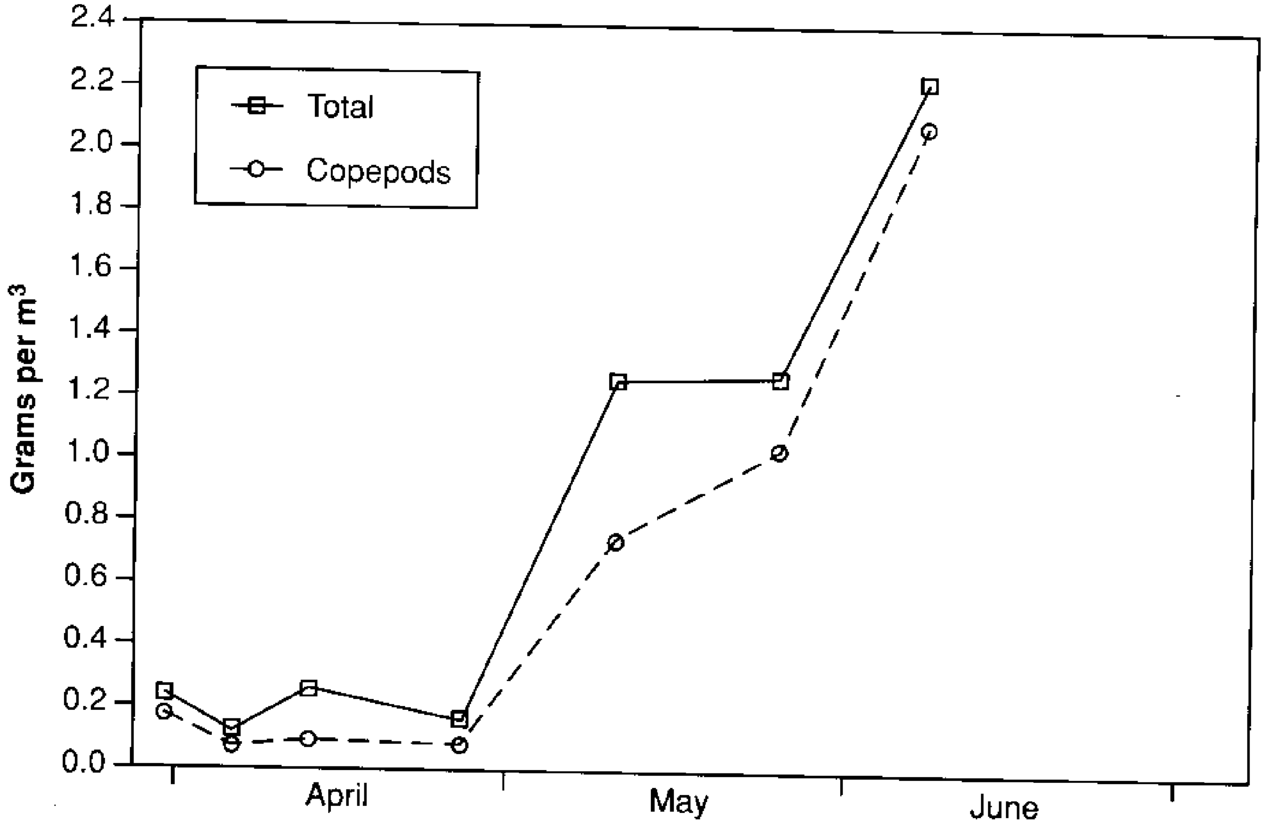

Figure 2. Zooplankton wet weight biomass at station R4 in outer Resurrection Bay, Alaska, spring 1988.

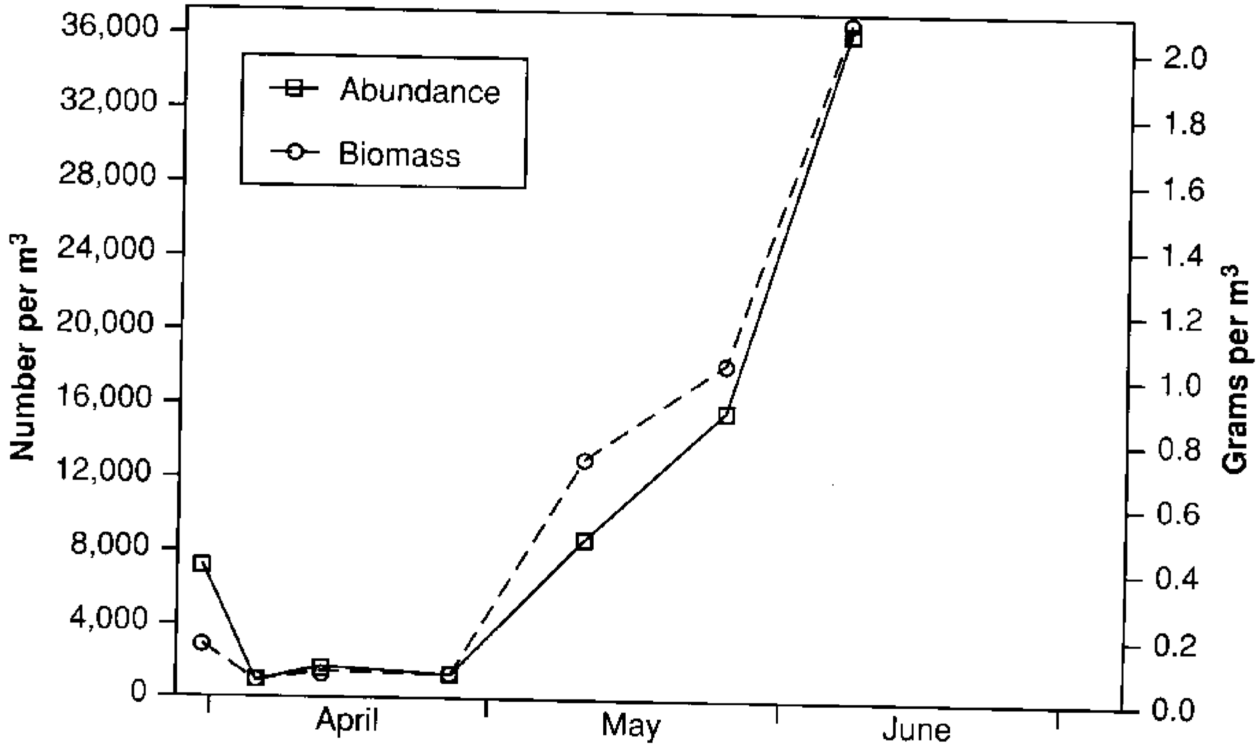

Figure 3. Total copepod abundance and biomass at station R4 in outer Resurrection Bay, Alaska, spring 1988.

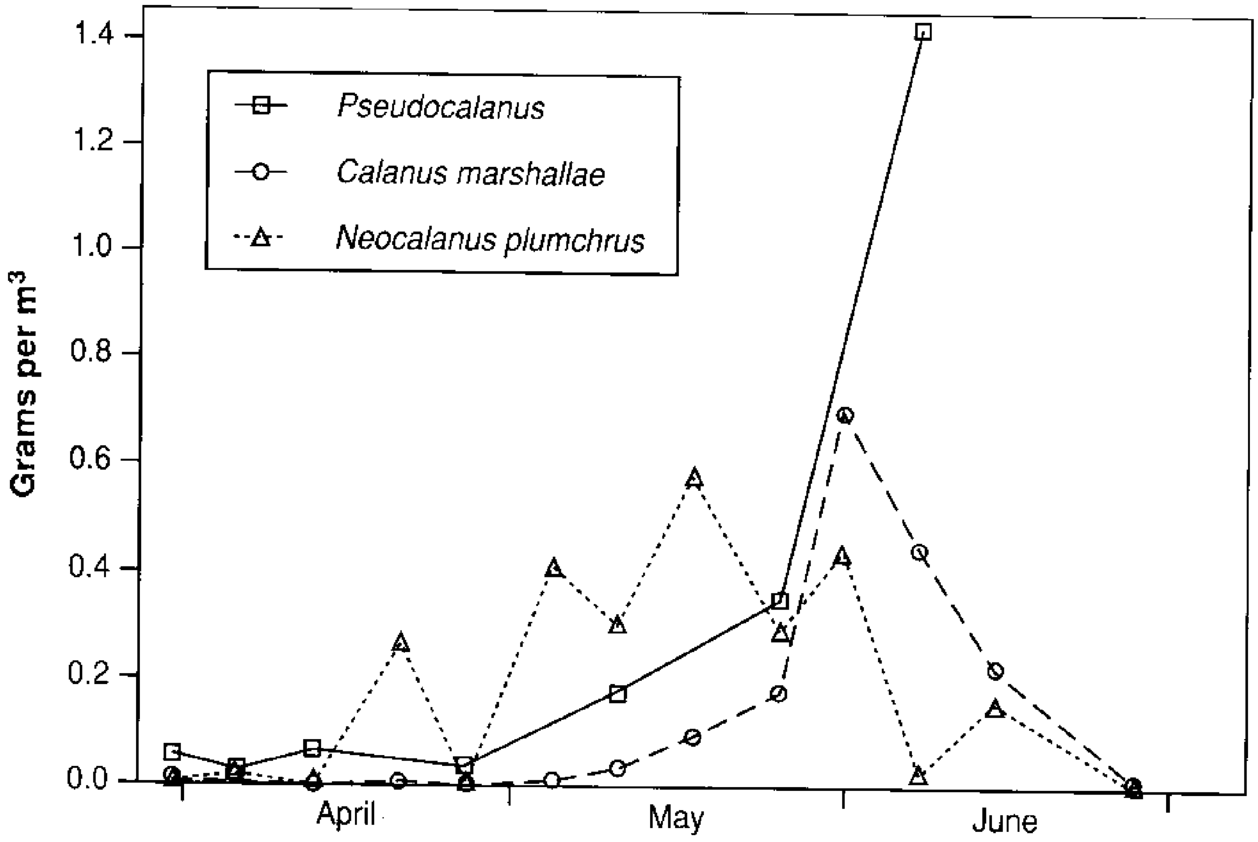

Figure 4. Wet weight biomass for copepod species at station R4 in outer Resurrection Bay, Alaska, spring 1988.

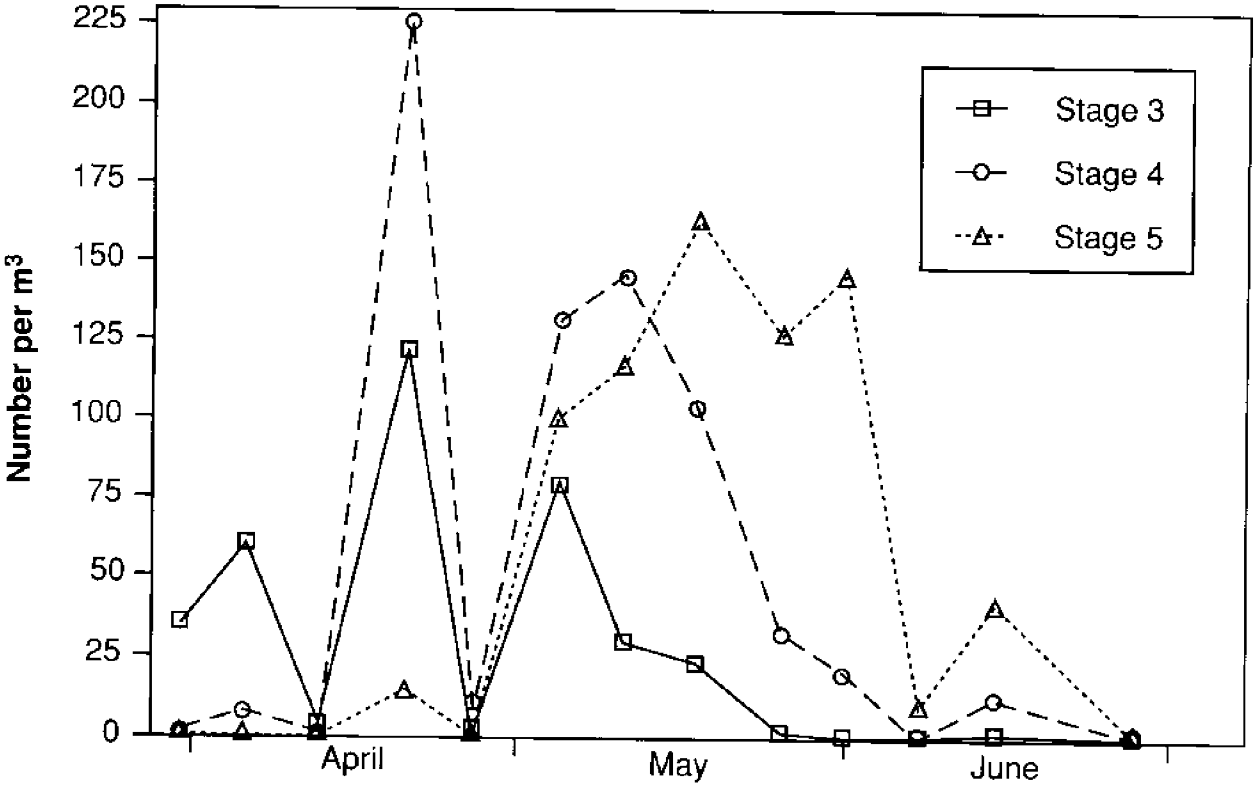

Figure 5. Neocalanus plumchrus abundance by stage at station R4 in outer Resurrection Bay, Alaska, spring 1988.

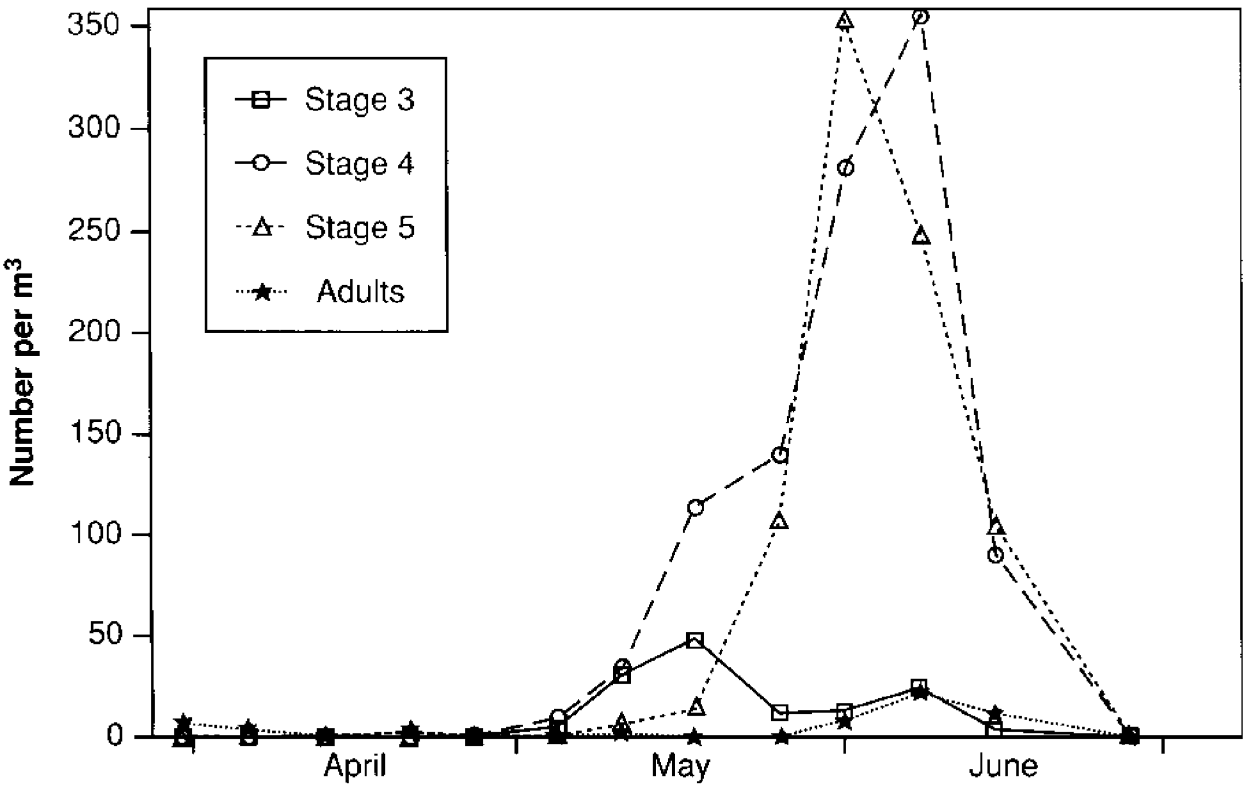

Figure 6. Calanus marshallae abundance by stage at station R4 in outer Resurrection Bay, Alaska, spring 1988.

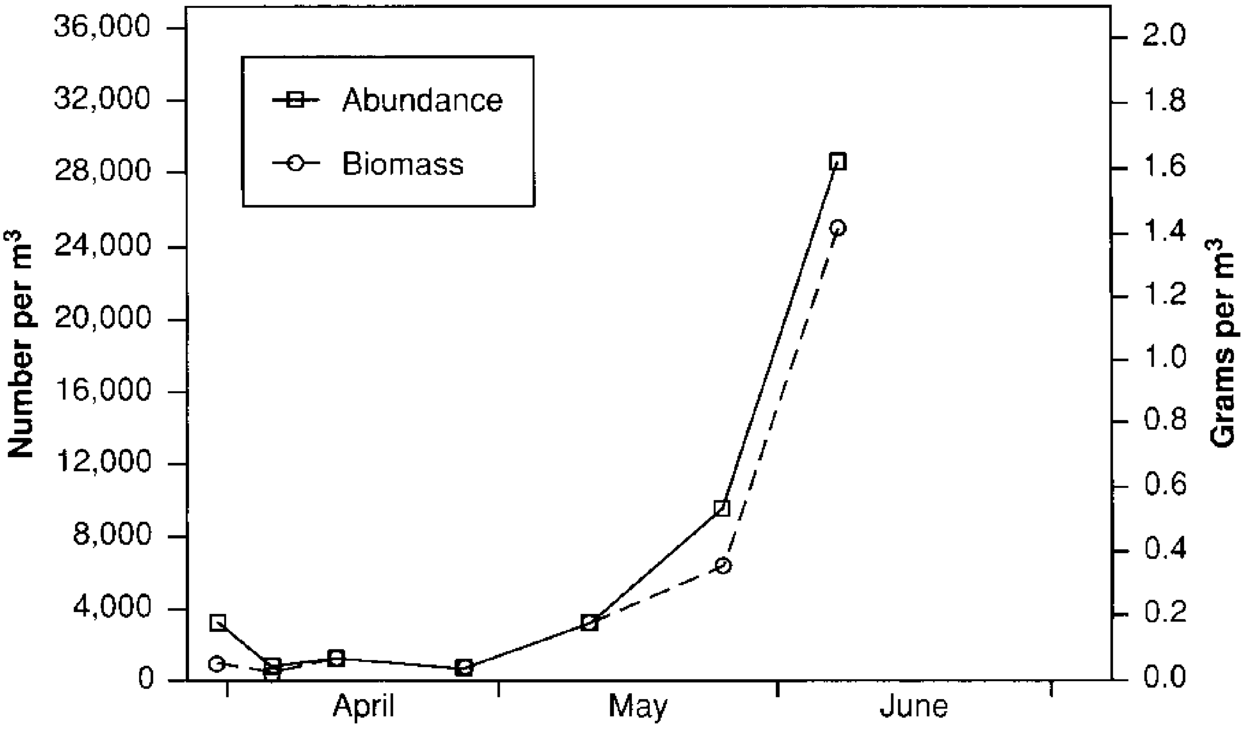

Figure 7. Pseudocalanus spp. abundance and wet weight biomass at station R4 in outer Resurrection Bay, Alaska, spring 1988.

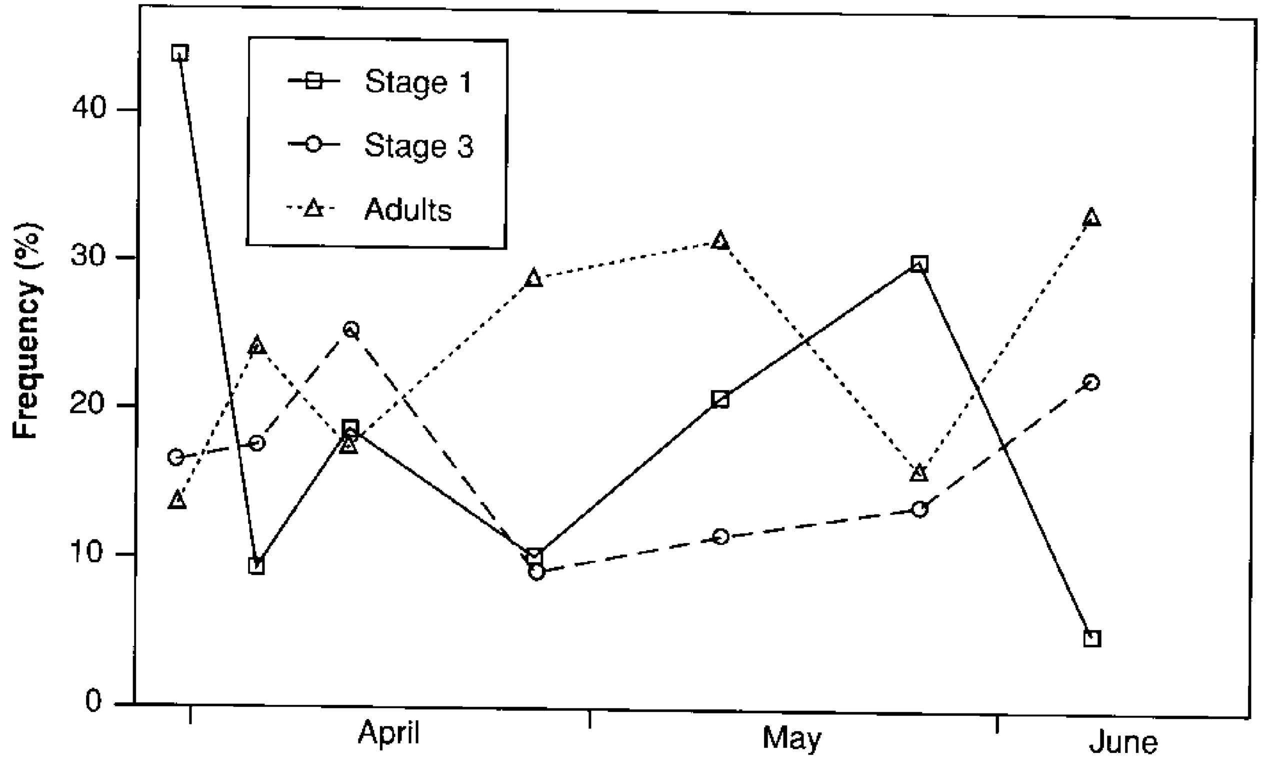

Figure 8. Abundance of *Pseudocalanus* spp. stages at station R4 in outer Resurrection Bay, Alaska, spring 1988.

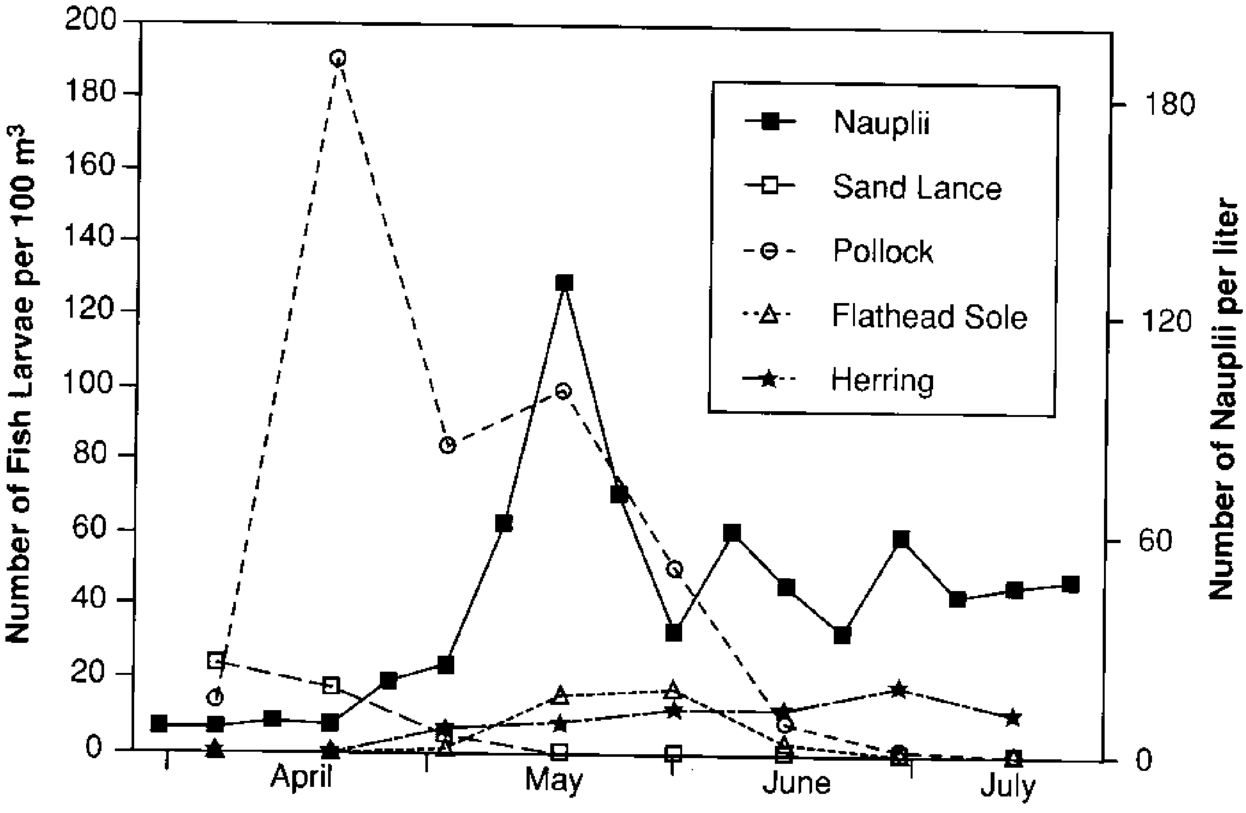

Figure 9. Copepod nauplii abundance (150–350 μm length) at 10 m depth and fish larvae in Resurrection Bay, Alaska, 1988. Values are averages for counts from stations R1, R2.5, and R4.

Table 1. Phytoplankton counts (cells per ml) taken at 10 m depth from Resurrection Bay stations R1, R 2.5, and R4 in 1988.

		Chae	Cyli	Skel	Ba	Thl	Nit	Lau	Eu	St	Lep	Flag	Pn	Un	Total
31 March	R1	10	79	92	0	0	0	0	0	0	0	0	51	3	235
	R2.5	2	52	5	14	7	0	0	0	0	0	0	35	0	115
	R4	2	14	2	5	5	0	0	0	0	0	0	12	0	40
6 April	R1	3	40	17	4	7	0	0	0	0	0	0	31	0	102
	R2.5	8	133	95	8	49	0	0	0	0	0	0	87	0	380
	R4	38	121	111	35	3	0	0	0	0	0	0	41	0	349
13 April	R1	73	51	95	0	13	98	38	0	0	0	0	0	0	368
	R2.5	138	43	209	0	38	119	199	0	0	0	0	0	0	746
	R4	152	9	104	0	16	63	98	6	16	9	0	0	0	473
21 April	R1	19	86	33	0	14	19	69	0	0	0	0	28	0	268
	R2.5	22	28	22	0	54	16	161	0	0	0	0	44	0	347
	R4	82	57	28	0	16	10	114	3	0	0	0	22	0	332
27 April	R2.5	76	57	109	0	33	62	162	19	0	24	0	10	0	552
	R4	218	28	100	0	14	71	81	0	0	5	0	19	0	536
5 May	R1	44	35	98	0	19	32	79	0	0	0	0	28	6	341
	R2.5	60	44	108	0	16	28	44	3	0	0	0	22	6	331
	R4	864	10	665	0	10	48	19	0	0	0	0	19	38	1,673
11 May	R1	95	63	298	0	190	0	6	0	0	6	0	0	0	658
	R2.5	82	63	241	0	6	222	13	0	0	6	0	0	0	633
	R4	1,102	0	1,254	0	38	418	0	0	0	456	0	0	0	3,268
18 May	R1	38	19	190	0	437	0	0	0	0	0	0	2,489	0	3,173
	R2.5	57	57	152	0	437	0	0	0	0	0	0	2,356	0	3,059
	R4	931	19	314	0	124	142	0	0	0	86	0	76	0	1,692
26 May	R1	10	10	470	0	0	62	0	0	0	0	0	19	0	571
	R2.5	0	57	884	0	0	48	0	0	0	0	0	95	0	1,084
	R4	51	76	1,305	0	0	101	0	0	0	0	0	89	0	1,622
1 June	R1	0	3	19	0	0	3	3	0	0	0	253	38	0	319
	R2.5	0	0	5	0	0	0	0	0	0	0	470	19	0	494
	R4	19	266	76	0	0	38	0	0	0	0	1,995	304	0	2,698
8 June	R1	0	5	0	0	0	0	0	0	0	0	461	28	0	494
	R2.5	0	28	0	0	0	0	0	0	0	0	874	57	0	959
	R4	0	309	0	0	0	0	0	0	0	0	1,971	1,045	0	3,325
15 June	R1	19	399	0	0	0	0	0	0	0	0	1,672	361	0	2,451
	R2.5	0	4,275	0	0	0	0	0	0	0	0	2,565	522	0	7,362
	R4	0	950	0	0	0	0	0	0	0	0	4,218	152	0	5,320
22 June	R1	0	291	0	0	0	0	0	0	0	0	912	63	0	1,266
	R2.5	0	413	0	0	0	0	0	0	0	0	510	185	0	1,108
	R4	0	76	0	0	0	0	0	0	0	0	294	656	0	1,026
28 June	R1	0	722	0	0	0	0	0	0	0	0	1,026	152	0	1,900
	R2.5	0	1,368	0	0	0	0	0	0	0	0	4,218	456	0	6,042
	R4	0	874	0	0	0	0	0	0	0	0	1,824	1,292	0	3,990
5 July	R1	0	118	0	0	0	0	0	0	0	0	726	25	0	869
	R2.5	0	747	0	0	0	0	0	0	0	0	608	127	0	1,482
	R4	0	69	0	0	0	0	0	0	0	0	1,624	86	0	1,779
13 July	R1	0	28	0	0	0	0	0	0	0	0	185	14	0	227
	R2.5	0	66	0	0	0	0	0	0	0	0	940	38	0	1,044
	R4	0	165	0	0	0	0	0	0	0	0	1,051	127	0	1,343
20 July	R1	0	51	0	0	0	0	0	0	0	0	225	3	0	279
	R2.5	0	95	0	0	0	0	0	0	0	0	519	51	0	665
	R4	0	76	0	0	0	0	0	0	0	0	998	0	0	1,074

Phytoplankton species: Chae = *Chaetoceros*; Cyli = *Cylindrotheca*; *Skel* = *Skeletonema*; Ba = *Bacteriosira*; Thl = *Thalassiosira*; Nit = *Nitzchia*; Lau = *Lauderia*; Eu = *Eucampia*; St = *Stephanopyxis*; Lep = *Leptocylindrus*; Flag = Flagellates; Pn = Unidentified Pennates; Un = Unknown cells; Total = Total cells/ml.

Table 2. Copepod nauplii counts (number per liter) collected at 10 m depth at Resurrection Bay stations R1, R2.5, and R4 in 1988.

		Nauplii length (μm)		
		<150	150-350	>350
31 March	R 1	0	1.2	0.1
	R2.5	0	6.3	0.3
	R4	0	1.0	0
6 April	R1	1.7	6.1	0.1
	R2.5	0.5	5.6	0.2
	R4	0	3.8	0.3
13 April	R1	0.1	4.6	0
	R2.5	0.1	8.0	0.7
	R4	0.1	5.8	0.4
21 April	R1	0.8	9.0	0
	R2.5	0.3	6.9	0.1
	R4	2.2	11.9	0.6
27 April	R1	(no sample)		
	R2.5	1.2	18.9	0.2
	R4	0.2	9.0	0
5 May	R1	0.4	23.7	0
	R2.5	1.0	24.2	0.4
	R4	0.4	25.8	1.0
11 May	R1	0.8	59.2	0
	R2.5	2.8	63.2	1.2
	R4	0.8	51.2	0
18 May	R1	0	139.2	0
	R2.5	16.0	128.8	0
	R4	6.4	105.6	0
26 May	R1	0.8	87.2	0
	R2.5	3.2	71.2	0
	R4	3.2	34.4	0
1 June	R1	0	39.2	0
	R2.5	3.2	32.8	0
	R4	4.0	45.6	0
8 June	R1	0.2	55.6	0
	R2.5	7.2	60.8	0
	R4	6.8	45.2	0
15 June	R1	0.8	79.6	0
	R2.5	2.0	46.4	0
	R4	5.6	20.8	0
22 June	R1	1.2	59.6	0
	R2.5	2.4	33.6	0
	R4	3.2	20.0	0
28 June	R1	1.2	57.2	0
	R2.5	8.4	60.4	0
	R4	0.6	8.8	0
5 July	R1	0	69.6	0
	R2.5	14.0	43.2	0
	R4	22.4	47.2	0
12 July	R1	0	49.2	0
	R2.5	5.6	46.0	0
	R4	11.0	43.2	0.2
20 July	R1	0.4	36.8	0
	R2.5	2.8	48.0	0
	R4	6.6	27.2	0

Table 3. Zooplankton abundance (number per 100 meter^3) at Resurrection Bay station R4 in spring 1988.

Taxon	31 March	6 April	13 April	27 April	11 May	26 May	8 June
Pseudocalanus I	123,589.10	5,772.02	19,919.13	5,704.11	49,231.93	244,462.01	108,649.77
Pseudocalanus II	80,129.20	7,130.14	17,655.59	7,877.11	42,441.32	166,369.97	119,514.73
Pseudocalanus III	46,176.15	10,864.98	27,162.45	5,160.86	27,162.45	110,347.42	478,058.94
Pseudocalanus IV	24,446.20	17,655.59	21,277.25	11,951.47	27,162.45	135,812.23	722,520.95
Pseudocalanus V	8,148.73	20,711.36	21,729.95	26,075.95	91,673.25	159,743.86	717,088.48
Pseudocalanus adults	38,027.42	14,939.34	18,561.00	16,297.47	74,696.72	128,205.14	711,655.96
Pseudocalanus (total)	320,516.80	77,073.43	126,305.37	73,066.98	312,368.12	944,940.63	2857,488.87
Calanus stage I	93,710.42	2,376.71	1,358.12	271.62	0.00	1,709.40	0.00
Calanus stage II	39,385.54	2,376.71	452.71	271.62	6,790.61	0.00	10,864.98
Calanus marshallae	649.00	355.81	47.04	11.12	7,676.79	26,265.32	65,685.53
Neocalanus plumchrus	3,719.05	6,877.27	462.58	878.78	29,371.84	16,350.76	1,191.87
Crangonidae zoeae	0.00	0.00	8.96	15.89	22.97	4.14	0.00
Hippolytidae zoeae	0.00	0.00	197.13	88.99	367.52	289.92	66.22
Anomuran zoeae	0.00	0.00	71.68	50.85	126.33	28.99	66.22
Oregoninae zoeae 1	0.00	0.00	2.24	7.95	189.50	28.99	20.7
Oregoninae zoeae 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brachyrhyncha zoeae	0.00	0.00	38.08	12.71	17.23	37.28	18.21

See Tables 6–9 for decapod larvae by species, and Figures 3–8 for additional copepod data.

Table 4. **Zooplankton wet weight biomass (grams per 100 meter^3) at Resurrection Bay station R4 in spring 1988.**

Taxon	31 March	6 April	13 April	27 April	11 May	26 May	8 June
Pseudocalanus I	0.8340	0.0390	0.1200	0.0410	0.1720	1.8330	0.7600
Pseudocalanus II	1.0420	0.0930	0.2780	0.0790	0.6230	1.5970	1.3540
Pseudocalanus III	0.8500	0.2000	0.9130	0.0680	0.7060	1.8760	7.1710
Pseudocalanus IV	0.8310	0.6000	1.3830	0.4400	1.3190	5.7380	19.5080
Pseudocalanus V	0.4030	1.1290	2.1680	1.8750	8.6440	9.5620	31.9920
Pseudocalanus adults	1.8640	0.9420	1.6340	1.3590	6.2610	14.6080	81.0640
Pseudocalanus (total)	5.8240	3.0020	6.4960	3.8630	17.7250	35.2150	141.8490
Calanus stage I	1.8270	0.0460	0.0620	0.0070	0.0000	0.0550	0.0000
Calanus stage II	2.2060	0.1330	0.0400	0.0210	0.5430	0.0000	0.8960
Calanus marshallae	0.7520	0.5210	0.0720	0.0060	3.4050	17.7370	44.3330
Neocalanus plumchrus	0.3870	1.9630	0.1110	0.6100	30.0720	29.2210	2.4500
Crangonidae zoeae	0.0000	0.0000	0.0060	0.0130	0.0230	0.0150	0.0000
Hippolytidae zoeae	0.0000	0.0000	0.0270	0.0250	0.3430	0.7830	0.2210
Anomuran zoeae	0.0000	0.0000	0.0480	0.0180	0.1660	0.0500	0.1150
Oregoninae zoeae 1	0.0000	0.0000	0.0010	0.0040	0.0630	0.0230	0.0290
Oregoninae zoeae 2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Brachyrhyncha zoeae	0.0000	0.0000	0.0150	0.0010	0.0010	0.0150	0.0180

See Figures 3–8 for additional copepod data.

Table 5. Euphausiid larvae density (number per meter^3) collected with a vertical haul from 10 m depth at Resurrection Bay station R1 in 1988.

	Eggs	Nauplii	Calyptopis
31 March	0	0	0
6 April	1.5	0.3	1.1
13 April	21.6	15.2	1.6
21 April	37.6	10.0	1.6
5 May	136.0	43.2	28.8
11 May	8.0	41.6	38.4
18 May	1.6	0	48.0
26 May	0	0	4.8
1 June	0	0	0

Table 6. *Chionoecetes bairdi* larvae abundance (number per 100 meter^3) sampled at Resurrection Bay stations R1, R2.5, and R4 in 1988.

		Stage		
		I	II	Megalopa
31 March	R1	12.8	0	0
	R2.5	0.8	0	0
	R4	0	0	0
6 April	R4	0.2	0	0
13 April	R1	36.9	0	0
	R2.5	2.4	0	0
	R4	3.9	0	0
21 April	R4	34.0	0	0
27 April	R2.5	15.1	0	0
	R4	22.2	0	0
5 May	R4	33.0	0	0
11 May	R1	270.8	0	0
	R2.5	245.2	0	0
	R4	183.5	0	0
18 May	R4	245.5	0	0
26 May	R1	0	0	0
	R2.5	17.2	1.6	0
	R4	25.3	0	0
1 June	R4	36.7	6.9	0
8 June	R1	0	3.1	0
	R2.5	0	0	0
	R4	0	0	0
15 June	R4	4.6	5.7	0
22 June	R2.5	0	0	0
	R4	1.1	2.2	0
28 June	R4	0	2.6	0
5 July	R4	0	0.5	1.4
12 July	R4	0	0	0.9
20 July	R4	0.3	0	0.3

Table 7. ***Pandalus borealis*** **larvae abundance (number per 100 meter^3) sampled at Resurrection Bay stations R1, R2.5, and R4 in 1988.**

		Stage*				
		I	II	III	IV	V
31 March	R1	0	0	0	0	0
	R2.5	2.2	0	0	0	0
	R4	2.3	0	0	0	0
6 April	R4	8.0	0	0	0	0
13 April	R1	92.8	4.8	0	0	0
	R2.5	182.9	19.5	1.2	0	0
	R4	455.9	17.6	0	0	0
21 April	R4	243.5	135.1	4.0	0	0
27 April	R2.5	11.7	30.7	12.2	0.5	0
	R4	8.3	9.0	3.5	0	0
5 May	R4	1.9	73.9	124.4	11.7	0
11 May	R1	0	0	0	4.5	0
	R2.5	0	8.0	106.7	54.1	0
	R4	0	50.0	236.3	77.8	0
18 May	R4	0	1.1	9.1	20.6	0
26 May	R1	0	0	0	0	0
	R2.5	0	0	1.6	0	0
	R4	0	0	1.8	14.5	12.7
1 June	R4	0	0	2.3	2.3	9.2
8 June	R1	0	0	0	1.5	0
	R2.5	0	0	0.9	0	0
	R4	0	0	0	0	0
15 June	R4	0	0	0	0.6	1.7
22 June	R2.5	0	0	0	0	0
	R4	0	0	0	0	4.4
28 June	R4	0	0	0	0	0.4

*No *P. borealis* stage VI were collected.

Table 8. *Pandalus platyceros* larvae abundance (number per 100 meter^3) sampled at Resurrection Bay stations R1, R2.5, and R4 in 1988.

		Stage*			
		I	II	III	IV
31 March	R1	38.4	0	0	0
	R2.5	4.6	0.5	0	0
	R4	1.6	1.6	0	0
6 April	R4	0.2	0	0	0
13 April	R1	1.9	3.6	0	0
	R2.5	7.3	0	0	0
	R4	6.9	1.0	0	0
21 April	R4	12.1	2.4	0	0
27 April	R2.5	1.0	0.5	0	0
	R4	0.7	0	0	0
5 May	R4	3.9	3.9	1.9	0
11 May	R1	0	0	9.0	0
	R2.5	3.2	6.4	3.2	1.6
	R4	0	11.1	8.3	0
18 May	R4	1.1	4.6	2.3	1.1
26 May	R1	0	1.5	0	0
	R2.5	0	0	0	0
	R4	1.8	0	5.4	0
1 June	R4	0	9.2	9.2	2.3
8 June	R1	0	0	0	0
	R2.5	0	0	0	0
	R4	0	0	2.1	4.1
15 June	R4	0	0	2.9	1.1

*No *P. platyceros* stages V or VI were collected.

Table 9. ***Pandalopsis dispar*** **larvae abundance (number per 100 meter^3) sampled at Resurrection Bay stations R1, R2.5, and R4 in 1988.**

		Stage*				
		I	II	III	IV	V
31 March	R1	0	0	0	0	0
	R2.5	0.3	0	0	0	0
	R4	0.8	0	0	0	0
6 April	R4	0.5	0	0	0	0
13 April	R1	1.2	0	0	0	0
	R2.5	1.2	0	0	0	0
	R4	0	0	0	0	0
21 April	R4	0	1.6	0	0	0
27 April	R2.5	0	0.5	0	0	0
	R4	0	0	0	0	0
5 May	R4	0	0	0	0	0
11 May	R1	9.0	4.5	0	0	0
	R2.5	1.6	0	0	0	0
	R4	0	0	0	0	0
18 May	R4	0	0	1.1	0	0
26 May	R1	0	0	9.6	0	0
	R2.5	0	0	0	1.6	0
	R4	0	0	0	1.8	0
1 June	R4	0	0	0	0	0
8 June	R1	0	0	0	18.5	0
	R2.5	0	0	0.9	5.8	0.9
	R4	0	0	0	0	0
15 June	R4	0	0	0	0	0
22 June	R2.5	0	0	0	0	0
	R4	0	0	0	0	1.1
28 June	R4	0	0	0	0.9	0
5 July	R4	0	0	0.4	0	0

*No *P. dispar* stage VI were collected.

Table 10. ***Theragra chalcogramma*** **larvae abundance (number per 100 meter^3) at Resurrection Bay stations R1, R2.5, and R4 in 1988.**

	R1	R2.5	R4
6 April	13	20	9
21 April	50	109	413
5 May	80	114	60
18 May	37	137	127
1 June	12	57	84
15 June	13	7	4
28 June	2	1	0
12 July	0	0	0

Table 11. ***Clupea harengus*** **larvae abundance (number per 100 meter^3) at Resurrection Bay stations R1, R2.5, and R4 in 1988.**

	R1	R2.5	R4
6 April	0	0	0
21 April	0	0	0
5 May	16	1	0
18 May	23	2	1
1 June	1	4	30
15 June	22	2	13
28 June	8	7	41
12 July	2	20	11

Table 12. ***Ammodytes hexapterus*** **larvae abundance (number per 100 meter^3) at Resurrection Bay stations R1, R2.5, and R4 in 1988.**

	R1	R2.5	R4
6 April	8	59	7
21 April	1	23	27
5 May	0	12	2
18 May	0	12	0
1 June	0	0	0
15 June	0	0	0
28 June	0	0	0
12 July	0	0	0

Table 13. ***Hippoglossoides elassodon*** **larvae abundance (number per 100 meter^3) at Resurrection Bay stations R1, R2.5, and R4 in 1988.**

	R1	R2.5	R4
6 April	0	0	0
21 April	0	0	0
5 May	1	1	1
18 May	13	24	8
1 June	1	25	26
15 June	1	1	3
28 June	1	0	0
12 July	0	1	0

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