Short Term Use of a Low Tide Refuge in a Sandflat by Juvenile Chinook, *(Oncorhynchus tshawytscha)*, Fraser River Estuary

C. D. Levings

Department of Fisheries and Oceans
Fisheries Research Branch
West Vancouver Laboratory
4160 Marine Drive
West Vancouver, British Columbia V7V 1N6

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SHORT TERM USE OF A LOW TIDE REFUGE IN A SANDFLAT BY JUVENILE CHINOOK, (*ONCORHYNCHUS TSHAWYTSCHA*), FRASER RIVER ESTUARY

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C. D. Levings

Department of Fisheries and Oceans

Fisheries Research Branch

West Vancouver Laboratory

4160 Marine Drive,

West Vancouver, B.C. V7V 1N6

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ABSTRACT

Levings, C. D. 1982. Short term use of a low tide refuge in a sandflat by juvenile chinook (Oncorhynchus tshawytscha), Fraser River estuary. Can. Tech. Rep. Fish. Aquat. Sci. 1111: iv + 33 p.

In May 1980 catch patterns, sizes, and diets of juvenile chinook salmon (Oncorhynchus tshawytscha) were examined in a low tide refuge in a sandflat on Sturgeon Bank, Fraser River estuary. Purse seine catches increased on falling tides. Fish caught around the perimeter of the refuge with a beach seine were about 10 mm smaller than those from simultaneous purse seining about 80 m offshore. Adult insects were abundant in stomachs in the early part of the ebb cycle, and cumaceans were consistently common in the diet. Neomysis mercedis abundance in stomachs showed a peak shortly after low water. Invertebrate catches in a 1 m deep drift sampler with 6 vertical nets were highest when tidal currents were strongest, increasing over 3 orders of magnitude. Adult insects were caught only in the surface nets, mysids in the bottom 2, and cumaceans were found in all 6 nets. The increased flux of invertebrates on falling tides or concentration of prey in reduced water volumes may influence food availability for fish. Low tide refugia may be critical habitats for juvenile chinook because of their increased concentrations and vulnerability to environmental effects at these locations.

RÉSUMÉ

Levings, C. D. 1982. Short term use of a low tide refuge in a sandflat by juvenile chinook (Oncorhynchus tshawytscha), Fraser River estuary. Can. Tech. Rep. Fish. Aquat. Sci. 1111: iv + 33 p.

En mai 1980, on a étudié les régimes de prises, la taille et l'alimentation des saumons quinnats juvéniles (Oncorhynchus tshawytscha) vivant dans un étang formé à marée basse sur la batture du banc Sturgeon, dans l'estuaire du fleuve Fraser. Les prises à la senne coulissante ont augmenté au moment du retrait des eaux. Les poissons pris le long du périmètre de l'étang avec une senne de rivage mesuraient 10 mm de moins que ceux pris en même temps, avec une senne coulissante, à environ 80 m au large. Des insectes adultes étaient abondants dans les estomacs des poissons capturés au début de la marée descendante; la présence de cumacés dans l'alimentation était uniforme. L'abondance de Neomysis mercedis dans les estomacs a plafonné peu après la marée basse. Le plus grand nombre d'insectes a été recueilli à l'aide d'un échantillonneur dérivant d'une profondeur de 1 mètre munis de 6 filets verticaux, quand les courants de marée étaient les plus forts, représentant une augmentation dans une proportion de 1 à 3. Les insectes adultes n'ont été pris que dans les filets de surface, les mysidacés que dans les deux filets du bas, et les cumacés, dans les six filets. La quantité accrue des invertébrés au moment du retrait des eaux ou la concentration de proies dans les volumes aqueux réduits peuvent influer sur la disponibilité de la nourriture pour les poissons. Les refuges formés à marée basse peuvent constituer des habitats critiques pour les saumons quinnat juvéniles à cause de leurs concentrations accrues et leur vulnérabilité aux effets environnementaux à ces endroits.

INTRODUCTION

Although the estuarine ecology of juvenile chinook salmon in B.C. estuaries has been documented in brackish marshes (e.g. Levy et al. 1979) and eelgrass (e.g. Healey 1980), there are few data available from other habitats. This report provides observations made at a low tide refuge or pit in a sandflat on Sturgeon Bank, Fraser River estuary. The first indicators of juvenile salmonid use of this pit were obtained during a preliminary survey of the Bank in 1979 (Greer et al. 1980). The work reported here focussed on medium scale and short term habitat differences in space and time. The size distribution of juvenile chinook was compared on a space scale of tens of metres, and differences in fish catches, prey abundance, and water characteristics were measured over tidal cycles. A more extensive, long-term study compared the present study area with 2 other locations on the Fraser foreshore. This project began in March 1980 and ended in July 1981 and therefore is complementary to the present study. Fish catch data from the extensive project are presently only available in a data report (Conlin et al. 1982).

DESCRIPTION OF THE STUDY AREA

Luternauer (1976) described the geomorphology of Sturgeon Bank, which is a very large (approximately 7000 ha) sand platform facing the southern Strait of Georgia (Fig. 1) with a narrow fringe of brackish marsh adjacent to the dykes which form its landward boundary. Our study area was approximately 4 km seaward of this vegetation (Fig. 1). Sampling was focussed on Steveston pit, which is a relict river channel on the southwest, seaward sector of Sturgeon Bank (Fig. 1). Until the South Arm of the Fraser began to be dredged, channelized and/or trained in the late 1800's, this channel was one of the main distributaries of the river. Water from one-half the area of Sturgeon Bank (about 3000 ha) drains into this channel on lower tides because of the morphology of the watershed on this part of the bank.

A sandbar demarcating the southwest shore of the channel begins to dry when tide levels falls to approximately 1.0 m in relation to chart datum (Fig. 1). The northeast and south shores begin to dry on a 0.2 m tide. To the west (seaward), a complex system of shallow channels connects the pit to the Strait of Georgia. These channels never dry completely, but only 0.5 m or less of water is present at extreme low tides. The system of shallow channels is therefore a sill separating the pit from the Strait of Georgia. The deepest part of the channel is adjacent to the southwest sandbar, where bottom is located at about 4.0 m below chart datum. The bathymetry of the pit is shown in Fig. 1.

FIELD PROCEDURES

A. Locating the pit

A buoy was anchored on the southwest sandbar, enabling personnel to locate the pit at high water. Access to Sturgeon Bank was via Garry Point channel adjacent to Steveston Harbour where the research barge L. PACIFICA was moored. Inflatable boats (5 m and 3 m) were used in sampling.

B. Fish sampling

For beach seining a 14.7 m beach seine was used, with wings 4.9 (1 cm stretched mesh), bunt 4.9 m (3 mm mesh), and depth 1.5 m. The seine was fitted with about 10 gillnet type floats and a leadline. The net was set by pulling it off the beach by boat and then was hauled in by hand using lines about 15 m in length. A similar net was modified for purse seining by fitting a purse line, with a quick release hook, by adding a few more gillnet floats, and by installing an inflated buoy on one end of the net. The buoy was used as a target when the net was fleeted out and the boat was guided in a circle for pursing.

Stations used for beach seining were dependent on tide levels. On the lowest tides 6 stations around the perimeter of the pit were sampled. A location in the deepest part of the pit was chosen for purse seining (Fig. 1).

Fish samples were fixed in 10% formalin.

C. Invertebrate sampling

A drift or ladder sampler (Fig. 2), was used for sampling invertebrate prey potentially available for juvenile salmonids. This device, built of aluminum and fitted with six nets with mesh size 200 um was fabricated following the description of Ellertsen (1979) who used it as a pushnet for sampling neuston.

We used the device in both the floating and benthic mode but results in this report were obtained using the former technique. In the floating mode styrofoam floats were used to suspend the device so it sampled from the surface of the water down to 1 m. In the benthic mode the sampler rested on the bottom and was supported in tidal flows by steel rods pushed into the sand. A flow meter was used to measure volumes of water passing through the various nets. Usually a sample was obtained in a 10 min set. On a few occasions, a gasoline powered pump was also used to sample invertebrates, and discharge from the pump was passed through netting with mesh size 200 um.

In the floating mode the drift net was deployed where replicate purse seines were made, that is offshore of the sandbar (Fig. 1). Pump samples were also obtained here. Invertebrate samples were fixed in 10% formalin.

D. Oceanographic observations

The majority of oceanographic data were obtained with a Beckman RS5-3 in situ salinometer, coincident with fish and invertebrate sampling, at the "offshore" station (Fig. 1). With the collaboration of Dr. P. Crean, Ocean Sciences and Surveys, observations of currents, salinity, and temperature in the pit were also made from the survey launch BRISK on July 7, 1980 over a 8 h period, during a rising and falling tide. On this occasion currents were measured with a Marsh-McBirney electro-magnetic current meter. Temperature, salinity, and depth were obtained with a CTD probe connected with an X-Y plotter on the launch.

LABORATORY METHODS

Fish were measured and guts examined within 2 months of sampling. Only counts of prey were obtained.

Invertebrate samples were sorted using a stereomicroscope and identified using standard keys. Detailed methods are presented elsewhere (Kotyk and Levings 1982).

RESULTS

A. Oceanography

Surface salinities in the pit ranged from approximately $5^{o}/_{oo}$ to $15^{o}/_{oo}$ during the study, and reflected the complex influence of the Fraser River on this part of Sturgeon Bank. On falling tides a front of fresh water from the river extends to the pit area, as shown in Fig. 3. The northeasterly spread of the river water is retarded when water levels fall below the level of the Steveston North Jetty. Surface temperatures ranged from 10°C in May to 18°C in July.

Subsurface temperature and salinity data indicate a salt wedge structure in the pit. Depending on ebb tide levels, relatively high salinity water from the Strait of Georgia must be trapped behind the sill. Whether this pool of water is replaced on each tidal stage is yet to be determined. During a very large ebb tide (amplitude difference 4.2 m) on May 15, the halocline structure broke down and low salinity water was apparently mixed to the bottom of the pit (Fig. 4). On a smaller ebb (2 m difference) on July 7, the salt wedge structure was preserved (Fig. 3).

Current velocities were not measured on the largest ebb tides and therefore peak velocities are not available. Our current data were obtained on the relatively small ebb (2 m difference) on July 7, when velocities of up to 100 cm s^{-1} were observed. On the larger ebbs in May and June, velocities were at least 3 or 4 times higher.

B. Patterns in chinook catches and diet

Beach seines on the southwest bar (Stations 5 and 6) yielded catches of juvenile chinook that were generally lower than those from the preliminary survey in June 1979. At the latter time two beach seines hauls caught 286 and 67 fish, respectively (Greer et al. 1980). In 1980, beach seine catches at Station 5 and 6 ranged from 2 to 45 per set, with a mean of 13 (S.D. = 13) over the period May to July (21 sets), in samples obtained in a complementary study (Conlin et al. 1982) Peak abundance was in May. When tide levels permitted, stations 1, 2, and 3 on the northeast perimeter of the pit were sampled. Catches at these stations were usually much higher than on the southwest sandbar, with a mean catch of 60 per set (S.D. = 129; n = 9). Station 4 at the study area was also sampled when possible but chinook were never taken at this location.

Purse seining on April 15, 16, and 28 (total of 17 hauls) yielded no chinook, but this species began to be taken in early May. Purse seining on the large ebb tides of May 5, 14, and 15 showed that chinook catches were highest at or near low tide (Fig. 5). The highest catch per set was 33, obtained at 1340 on May 15.

Juvenile chinook caught in the purse seine were larger than those taken by beach seine. Beach seine fish showed a mode in length frequency at 42 mm, whereas those taken by purse seine showed a broad peak in frequency from about 50 to 55 mm (Fig. 6). There was no significant difference, as judged by analysis of variance, of lengths for purse-seine caught fish taken at the various time periods on both May 14 and 15 ($F = 1.4$, df = 4, 68; $F = 1.5$, df = 3, 103, respectively; $p > 0.05$).

Chinook diets, estimated from purse-seine caught fish, showed temporal differences in composition. Adult insects dominated in the guts during the early part of the ebb on both May 14 and 15 (Fig. 7,8). On May 15 cumaceans (*Lamprops* spp.) were relatively consistent in guts throughout the sampling period but on May 14 the proportion increased at slack water and after (Fig. 7). *Neomysis mercedis* from chinook guts showed a peak in the early afternoon of May 14 but relatively little change between the 3 time periods sampled on May 15 (Fig. 8).

The stomach contents of beach (Station 6) and purse ("offshore" station) seine caught fish were compared at approximately 1330 h. on May 14. Fish from purse seines averaged 52 mm (SD = 8) and were significantly larger, as judged by analysis of variance ($F = 18.8$, df = 1, 66, $p < 0.05$) than beach seine chinook (mean size 45 mm, SD = 4). There was no statistically significant difference in number of prey per stomach from the beach and "offshore", for *Lamprops* spp. ($F = 0.95$, df = 1, 69, N.S.), for *Neomysis mercedis* ($F = 3.5$, df = 1, 69, N.S.) or for adult insects ($F = 1.15$, df = 1, 69, N.S.). Mean number per stomach, with standard deviation in parentheses, for the respective prey was as follows: beach 2.3 (4.9); 0.7 (0.9); 1.9 (3.5); purse - 5.5 (12.5); 1.3 (1.7); 3.6 (8.3).

Invertebrate prey sampling

Sampling with both the drift sampler and the plankton pump showed that drift insects, zooplankton, and epibenthic invertebrates were present in the pit. Tables 1 and 2 list some representative data and complete tabulations are shown elsewhere (Kotyk and Levings 1982). Epibenthic organisms such as gammarid amphipods, mysids, and cumaceans were obtained in the lower levels of the drift net, especially when the device was used in the benthic mode (Kotyk and Levings 1982). The vertical distribution and abundance of invertebrates varied with tidal currents, as shown by the data from May 14, increasing over 3 orders of magnitude when ebb currents were strongest (Fig. 8). There was also less stratification of organisms at this time. When used in the benthic mode, the lower nets on the drift sampler were usually filled with sand when tidal currents were strong, indicating movement of materials and benthic organisms (e.g. the bivalve Macoma balthica) in the bed load.

Figure 9 shows the temporal change in three major prey items from drift samples in the floating mode on May 14. Adult insects (mostly dipterans) were caught only in the surface net, and showed no obvious change in catch pattern with tide. Their abundance was always < 2 m^{-3}. Neomysis mercedis occurred only in the two bottom nets (water depth > 80 cm) and ranged in abundance up to 15 m^{-3}. The mysids began to occur at 1000, when ebb tide velocities were maximum. Lamprops spp. and Cumella vulgaris showed a similar increase but occurred in all 6 nets. Abundance at 1000 h was much higher in the lower net at this time, reaching 555 m^{-3} (Fig. 9). However, harpacticoid copepods, cladocerans, barnacle nauplii, calanoid copepods (especially juvenile calanoids, Eurytemora spp, and Oithona spinirostris) dominated the ladder sampler catches on May 14 (Table 1). Cumaceans (Cumella vulgaris and Lamprops spp.) (2.86%) and Neomysis mercedis (0.66%) were important prey species ranking among the 12 most abundant species, but adult insects only accounted for 0.05% of the total catch.

DISCUSSION

A. Fish distribution and size

Data on short-term temporal changes in the abundance of juvenile chinook in coastal waters have been presented by Levy et al (1979) for catches in tidal channels through brackish marshes in the South Arm of the Fraser, about 10 km upstream from the present study site. Using a tidal creek entrapment technique, chinook were found to be the last species of salmon leaving the tidal creeks as the tide ebbed (Levy et al. 1979). This collaborates our observations on changing abundance in the sandflat, as fish would be drained from marsh habitat on the Lulu Island foreshore to our study area. Present data (Greer et al. 1980) show that fish use these marsh areas.

The observation that smaller chinook fry use beach habitats whereas larger fish are slightly further offshore (Fig. 6) indicates habitat segregation on a scale not documented previously in the coastal zone. Size segregation, similar to that observed for chinook in streams may be occurring, an important result for those rating various coastal habitats in terms of importance to fish. Lister and Genoe (1970) found that chinook fry in the Big Qualicum River, B.C. (June 1967) were approximately 5 mm larger over boulders compared to gravel substrates, even when only 3 m separated the 2 habitats. Everest and Chapman (1972) found that chinook fry length was significantly correlated with velocity at focal point, surface velocity, and depth in an Idaho stream. Larger chinook were found offshore of the Nanaimo estuary (Healey 1980) but all of the latter author's work has been with beach and seine stations separated by at least several kilometres.

B. Prey availability

As frequently reported for other salmonids (e.g Sibert 1979) chinook only used certain prey items from the large suite of organisms potentially available as indicated by the drift and pump sampling data (Table 1, 2). The processes which lead to various epibenthic species becoming "available" to juvenile salmonids is a complex unresolved question discussed by several other authors (e.g. Hyatt 1979). In this study prey size might have been an important factor as the most abundant organisms in the drift sampler were smaller crustaceans such as cladocerans and larval stages of barnacles (Table 1). Chinook did not use these taxa. Stomach contents of chinook in the early part of the ebb cycle on May 14 (Fig. 7) indicated heavy use of adult insects, primarily dipterans, which could have been taken by the fish at high tide while in the brackish marshes of the high intertidal zone off Lulu Island. A similar conclusion was reached by Congleton (1979) who worked with juvenile chum in the Skagit River estuary in Puget Sound. An analysis of variance of the number of prey items per fish over the sampling times on May 14 and 15 indicated there was no significant difference ($F = 3.8$, df = 4, 7; $F = 2.7$, df = 3, 6; respectively; $p > 0.05$). Chinook were observed breaking water and jumping during our work, and were probably feeding on dipterans drifting through the study area. Because of the relatively small area sampled by the drift net there is some doubt these organisms were adequately sampled, and major shifts in abundance may have been missed. Water turbidity was extremely high and direct observations of fish feeding behaviour was impossible. If our sampling had been extended into dawn or dusk periods we might have found evidence for crepuscular feeding activity, as did Karpenko (1979) for larger chinook (81 to 141 mm) in a Kamchatka Bay.

Since the fish were feeding on invertebrates typically using near bottom habitats (e.g. mysids) as well as drift organisms on the surface (e.g. adult insects),there is little evidence that they were restricting their feeding activity to particular layers in the water column. The chinook apparently were penetrating a halocline to feed on the mysids, moving over a salinity gradient of $10^{o}/_{oo}$. During peak ebb currents, however, the halocline structure did break down (Fig. 4), and this may have been when chinook feeding intensity on near bottom organisms was highest. During peak ebb currents catches of invertebrates increased markedly, and this no doubt occurs regularly on each tidal cycle, as reported by Sibert (1981) and Alldredge and Hamner (1980) for other nearshore habitats. This concentrating effect or increased flux of invertebrates may influence food availability. However, further information, especially vertical distribution of the fish, is required to confirm this.

Habitat implications

Although present issues concerning the use of Fraser estuary habitats focus on marshes (e.g. Dorcey et al 1978) the data presented in this report and on-going research show that other habitats may be as important as vegetated areas, and in fact are inseparable because of water flow patterns. Further documentation and expansion of this concept will be forthcoming as results of the more extensive comparative studies (e.g. Conlin et al 1982) are interpreted.

Since chinook populations must be very dense in these low tide refugia because of reduced water volumes on low tides, these particular habitats may be critical ones for the juvenile fish. There may be increased intraspecific competition for food at these locations compared to the high tide situation, when fish can forage over a much greater area. In addition the fish would be much more vulnerable in the refugia to environmental effects such as a spill of toxic chemicals.

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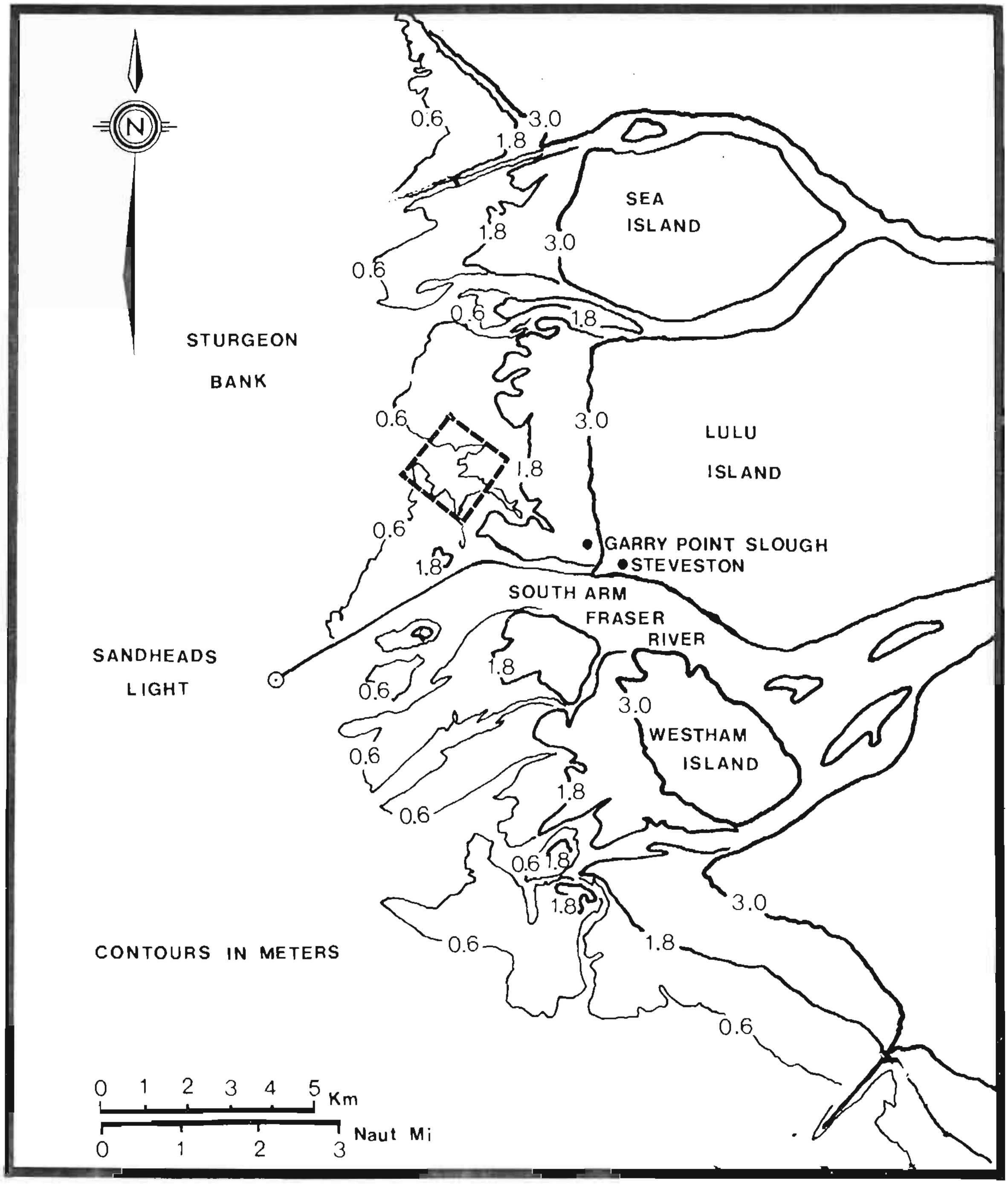
				TIME (PDT)				
TAXA	0828	0914	1013	1120	1410	1506	1600	TOTAL
Harpacticoid copepods	4.87	19.54	45.07	43.44	27.06	1.72	3.44	20.73
Cirriped nauplii	20.42	43.65	2.31	15.52	8.32	7.16	39.31	19.53
Eurytemora spp.	2.51	0.83	27.61	13.26	10.90	31.63	10.16	13.84
Podon polyphenoides	38.41	8.10	0.63	1.45	10.66	7.66	24.18	13.01
Juvenile calanoid copepods	0.65	15.41	1.56	2.57	18.96	39.43	10.78	12.77
Oithona spinirostris	23.77	3.57	3.57	3.15	2.12	9.37	0.35	6.60
Cirriped cyprids	8.83	2.29	0.52	0.95	5.69	0.29	0.92	2.78
Cumella vulgaris	-	0.01	11.64	4.12	2.77	0.32	0.44	2.76
Copepod nauplii	0.06	1.56	0.63	4.45	0.47	0.42	0.57	1.17
Oligochaeta	-	-	0.51	0.35	4.77	0.51	0.35	0.93
Neomysis mercedis	-	-	0.23	0.94	2.50	0.78	0.18	0.66
Acartia longiremis	-	-	-	-	-	0.02	4.47	0.64

Table 1. Right hand column lists percent of taxa accounting for the majority of catches from the ladder sampler (floating mode, data from all nets combined) on May 14 1980. Percentages at particular sampling times are given in columns to left.

TAXA	DEPTH OF SAMPLE 0 m	1.5 m	3.0 m
Acartia longiremis	355	533	177
Eurytemora spp.	333	800	3911
Copepod nauplii	111	44	622
Juvenile calanoids	0	222	355
Harpacticoid copepods	0	222	2488
Cirriped nauplii	67	44	0
Podon polyphenoides	1377	2977	4088
Evadne nordmanni	1144	1022	533
Cumella vulgaris	67	44	711
Oikopleura sp.	0	0	8
Eogammarus confervicolus	0	44	0
Chironomid larvae	22	0	0
Parapleustes pugettensis	22	0	0
Unidentifiable gammarid	22	0	0
Oligochaetea	22	0	0

Table 2. Abundance (number m^{-3}) of organisms from pump samples at 3 depths over offshore station on June 11, 1980, 0930 h, water depth 3.2 m.

LIST OF FIGURES



0.6
3.0
1.8
SEA
ISLAND
1.8
3.0
0.6
0.6
1.8
STURGEON
BANK
0.6
3.0
LULU
ISLAND
1.8
0.6
GARRY POINT SLOUGH
STEVESTON
1.8
SOUTH ARM
FRASER
RIVER
SANDHEADS
LIGHT
1.8
0.6
3.0
WESTHAM
ISLAND
0.6
1.8
0.6
0.6
1.8
1.8
3.0
0.6
1.8
CONTOURS IN METERS
0.6
0 1 2 3 4 5 Km
0 1 2 3 Naut Mi

Fig. 1.

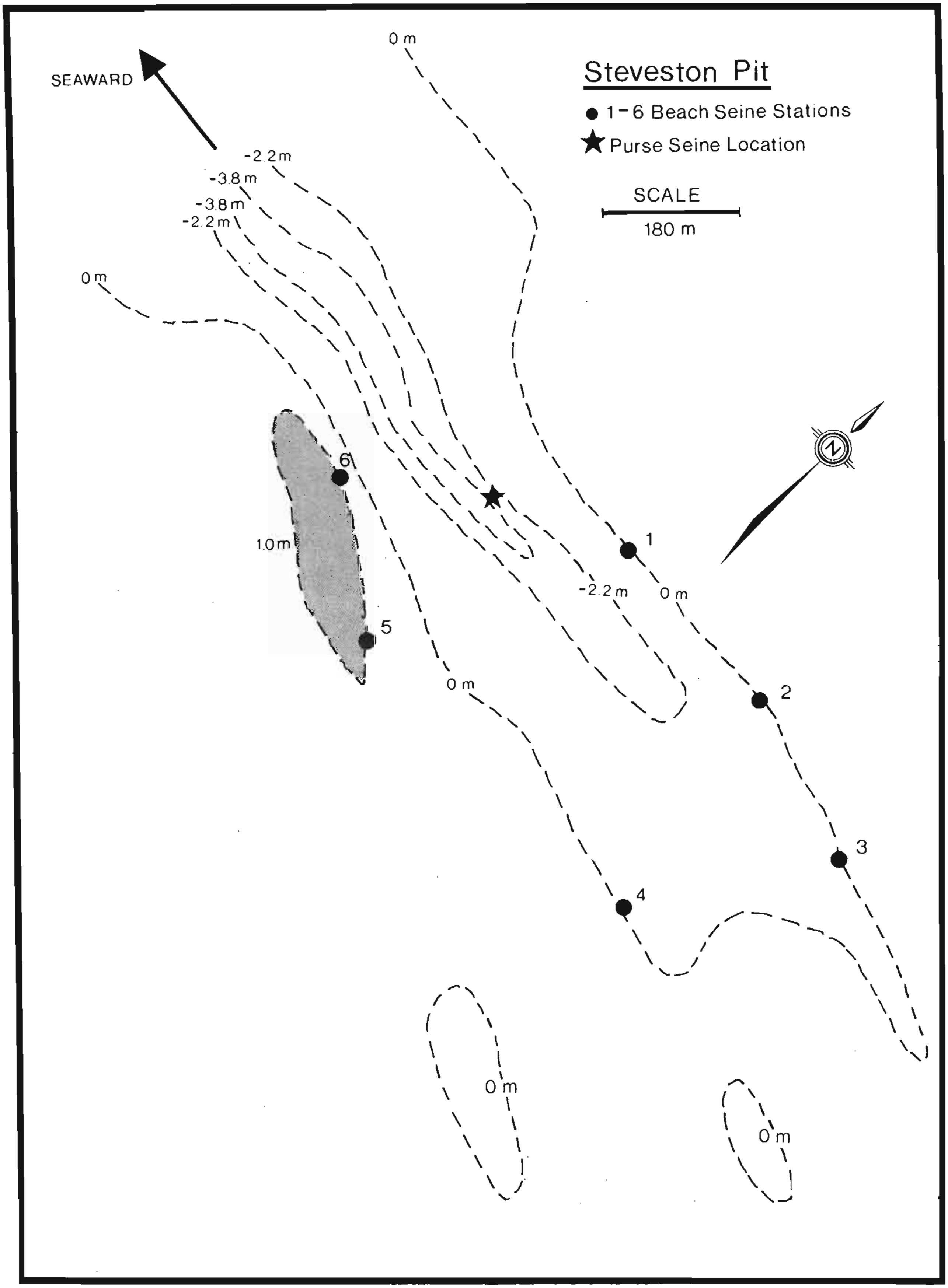

Steveston Pit
1-6 Beach Seine Stations
Purse Seine Location
SCALE
180 m
SEAWARD
0 m
-2.2 m
-3.8 m
-3.8 m
-2.2 m
0 m
1.0 m
-2.2 m
0 m
0 m
0 m
0 m
1
2
3
4
5
6
N

Fig. 1 (cont'd).

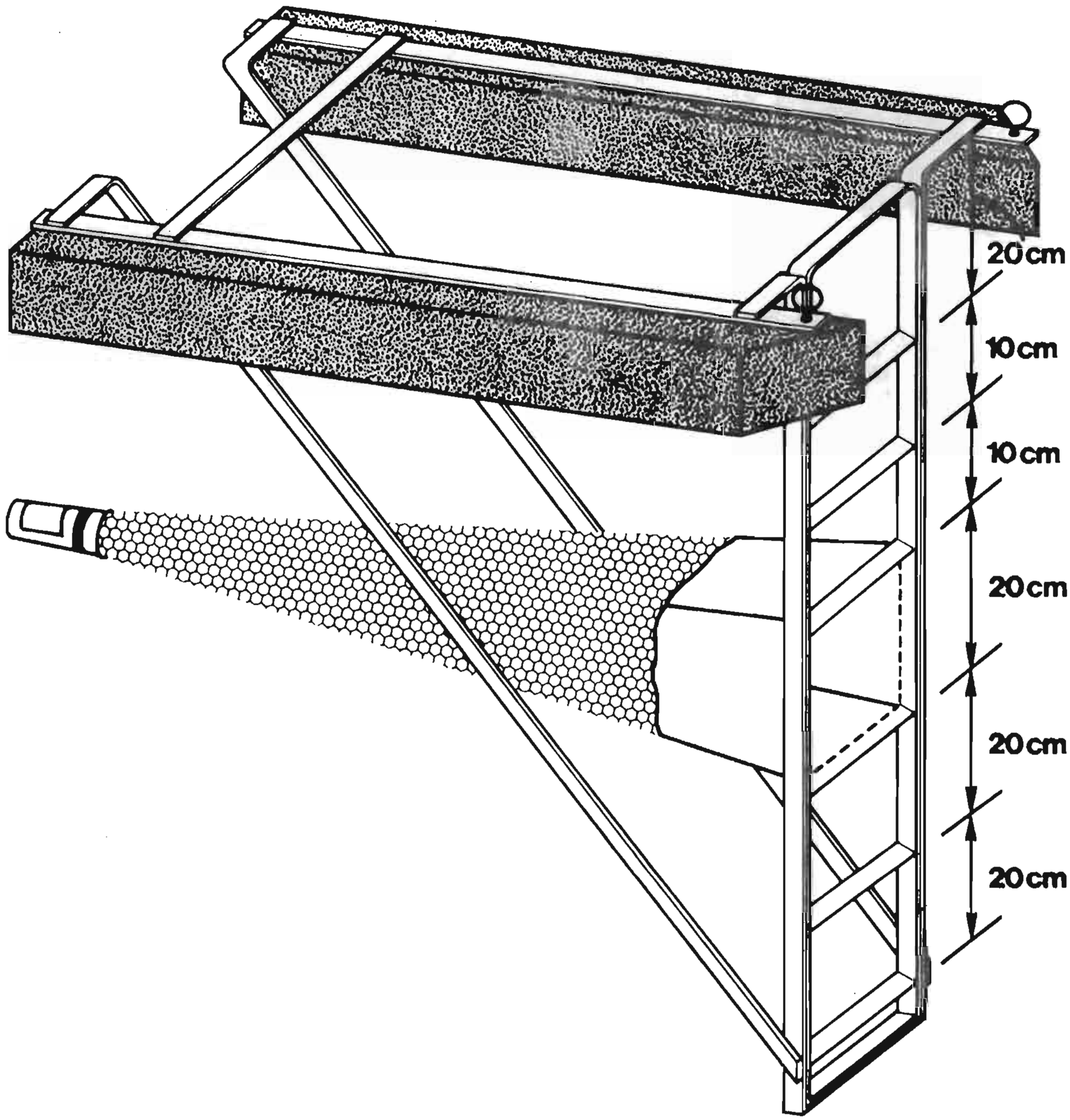
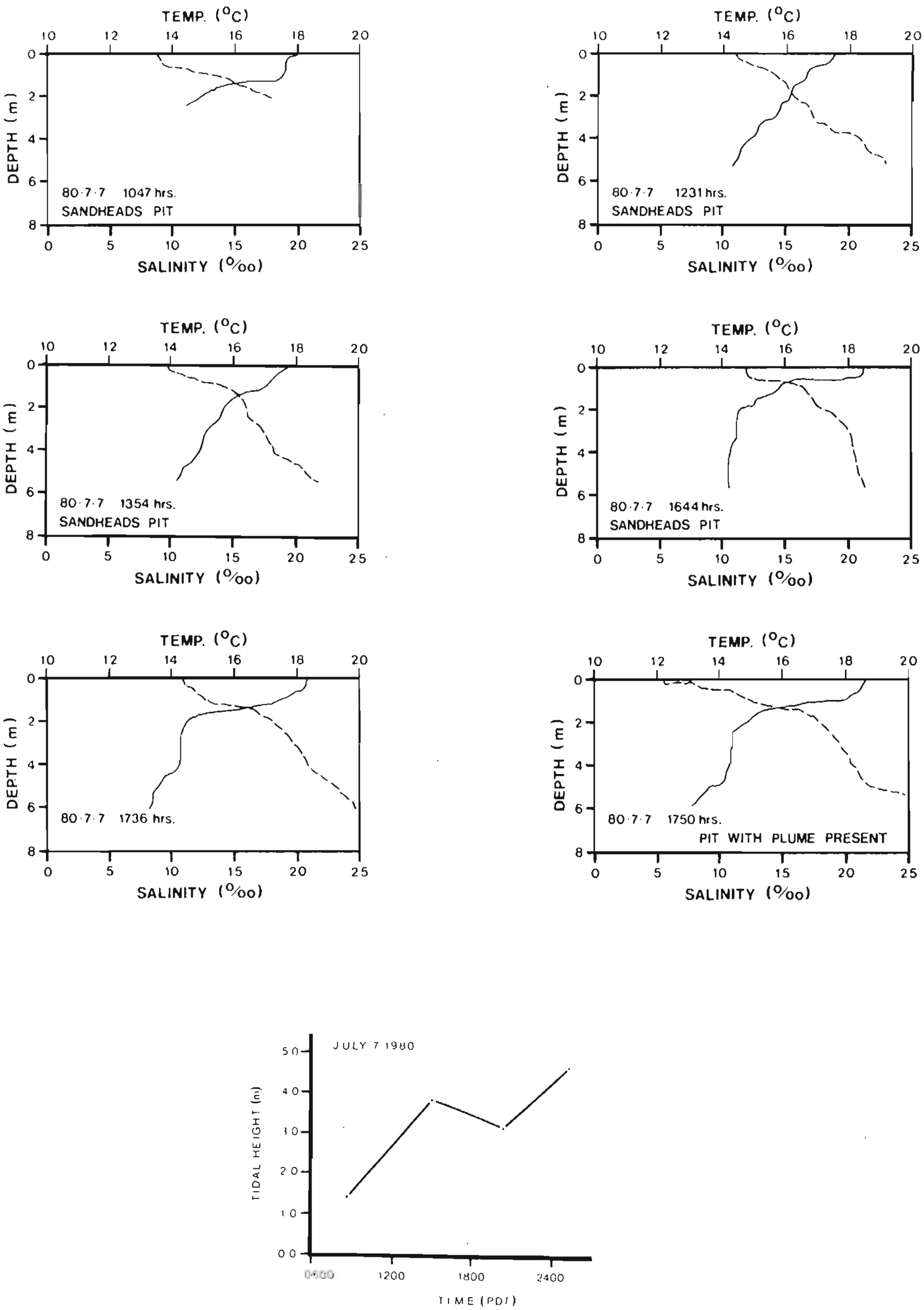


Fig. 2.



TEMP. (°C)
DEPTH (m)
SALINITY (‰)
80·7·7 1047 hrs.
SANDHEADS PIT
80·7·7 1231 hrs.
SANDHEADS PIT
80·7·7 1354 hrs.
SANDHEADS PIT
80·7·7 1644 hrs.
SANDHEADS PIT
80·7·7 1736 hrs.
80·7·7 1750 hrs.
PIT WITH PLUME PRESENT
JULY 7 1980
TIDAL HEIGHT (m)
TIME (PDT)
1200
1800
2400

Fig. 3.

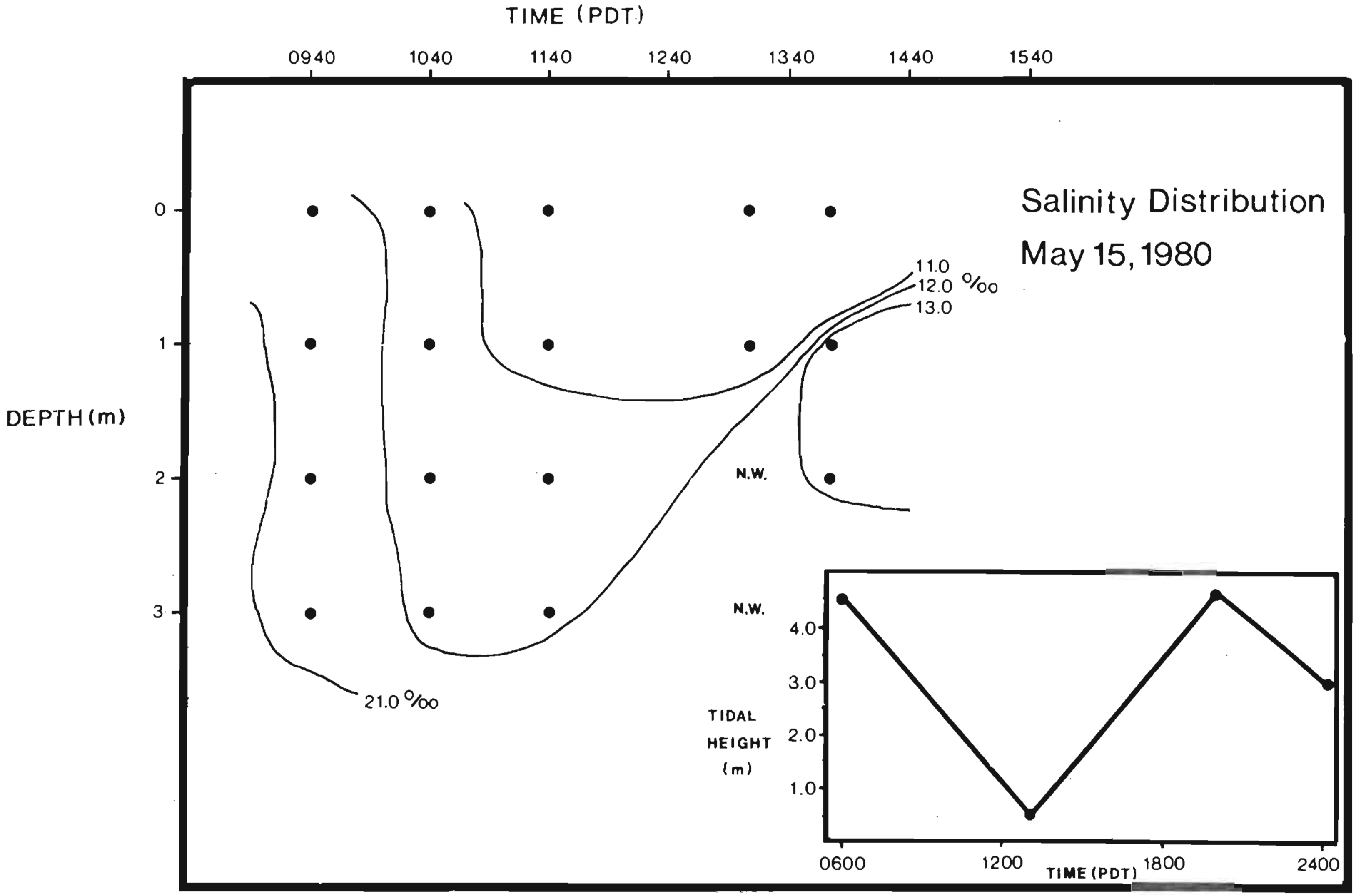
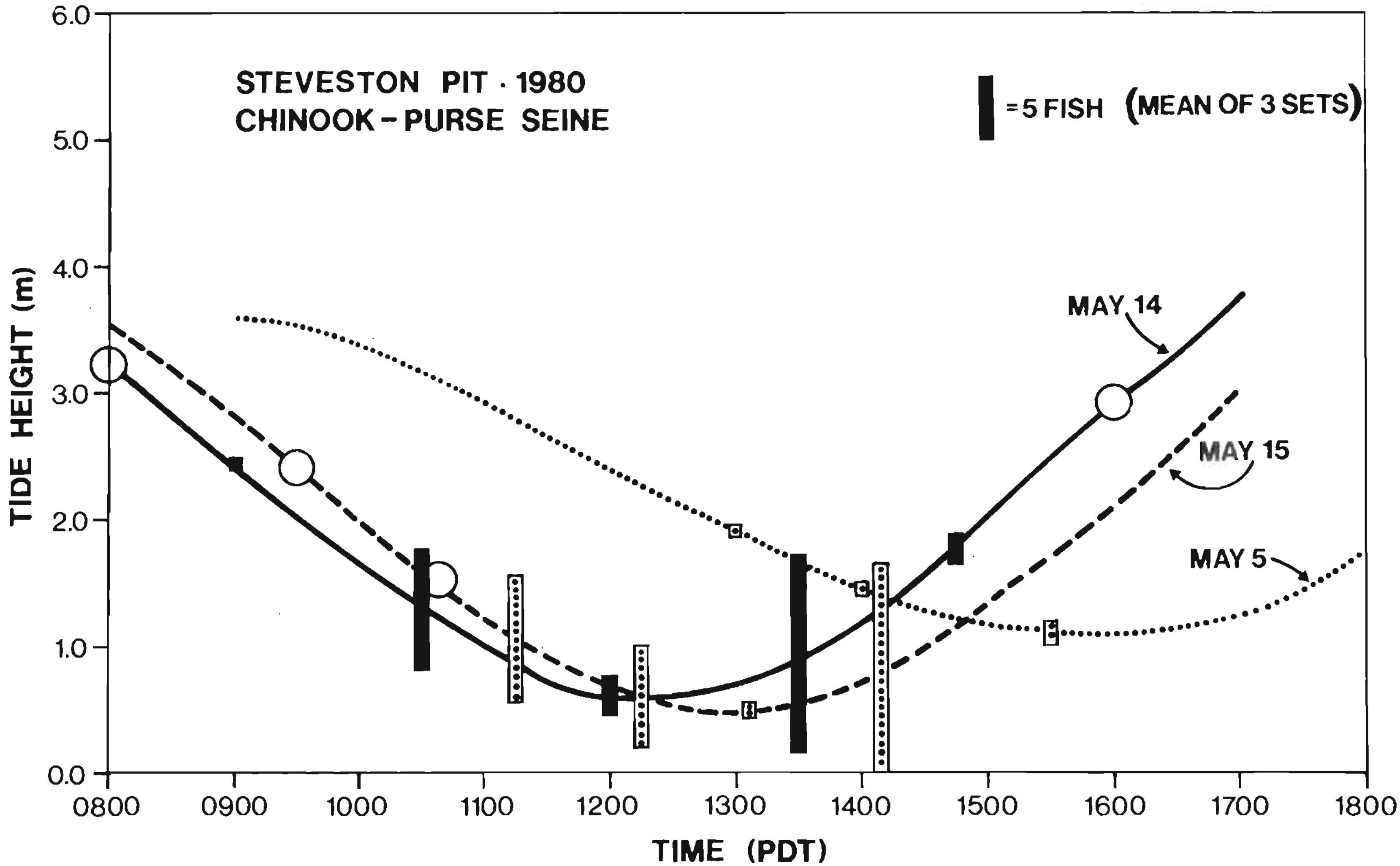

TIME (PDT)
0940
1040
1140
1240
1340
1440
1540
Salinity Distribution
May 15, 1980
DEPTH (m)
0
1
2
3
11.0
12.0 ‰
13.0
21.0 ‰
N.W.
N.W.
TIDAL HEIGHT (m)
4.0
3.0
2.0
1.0
0600
1200
1800
2400
TIME (PDT)

Fig. 4.



STEVESTON PIT · 1980
CHINOOK - PURSE SEINE
= 5 FISH (MEAN OF 3 SETS)
MAY 14
MAY 15
MAY 5
TIDE HEIGHT (m)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
TIME (PDT)

Fig. 5.

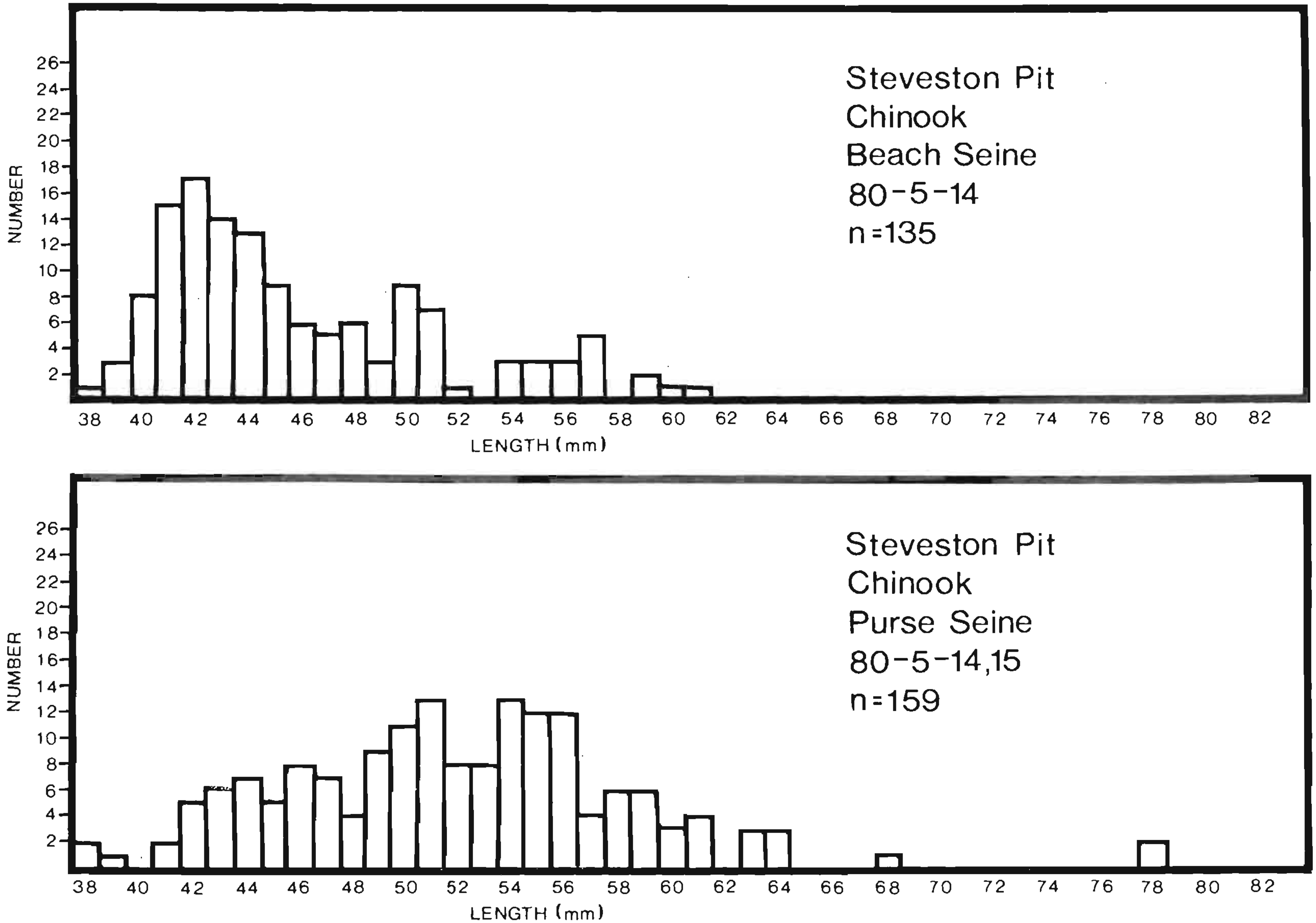

Steveston Pit
Chinook
Beach Seine
80-5-14
n=135
NUMBER
LENGTH (mm)
Steveston Pit
Chinook
Purse Seine
80-5-14,15
n=159
NUMBER
LENGTH (mm)

Fig. 6.

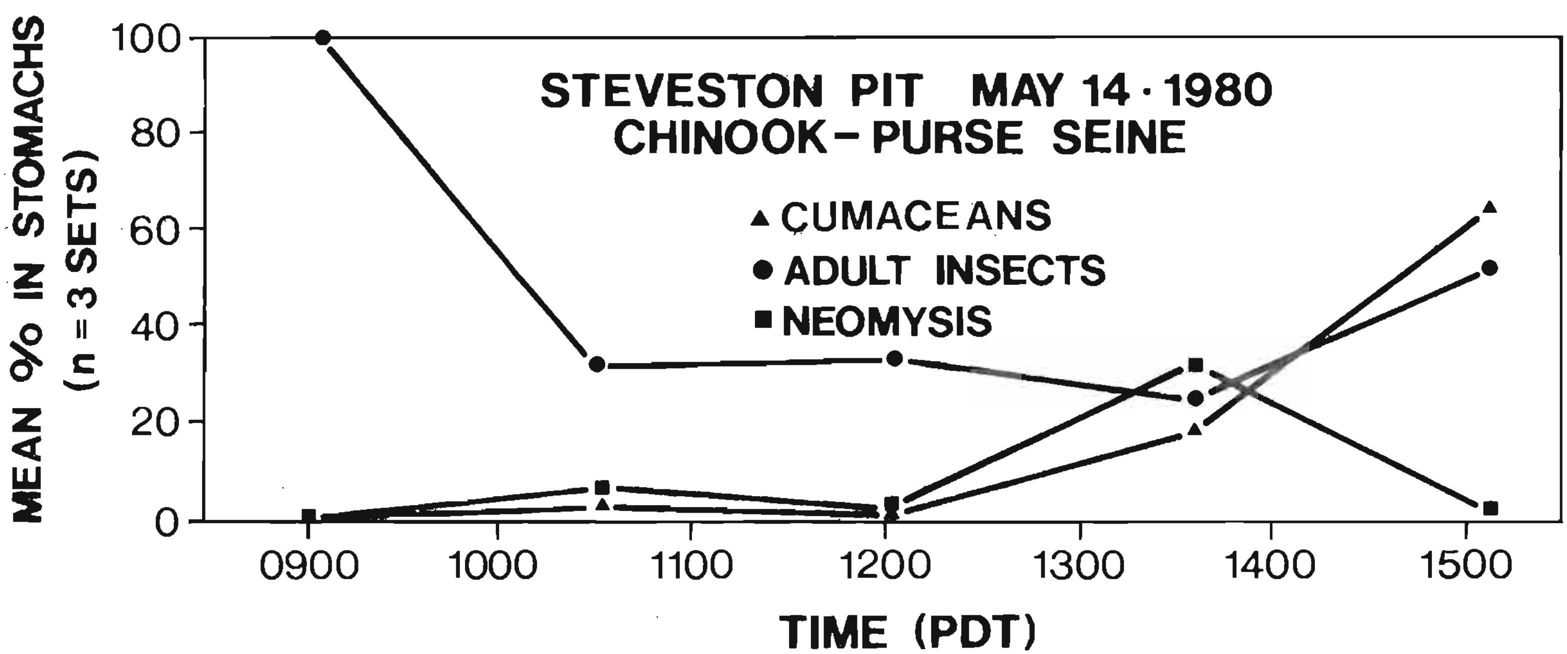
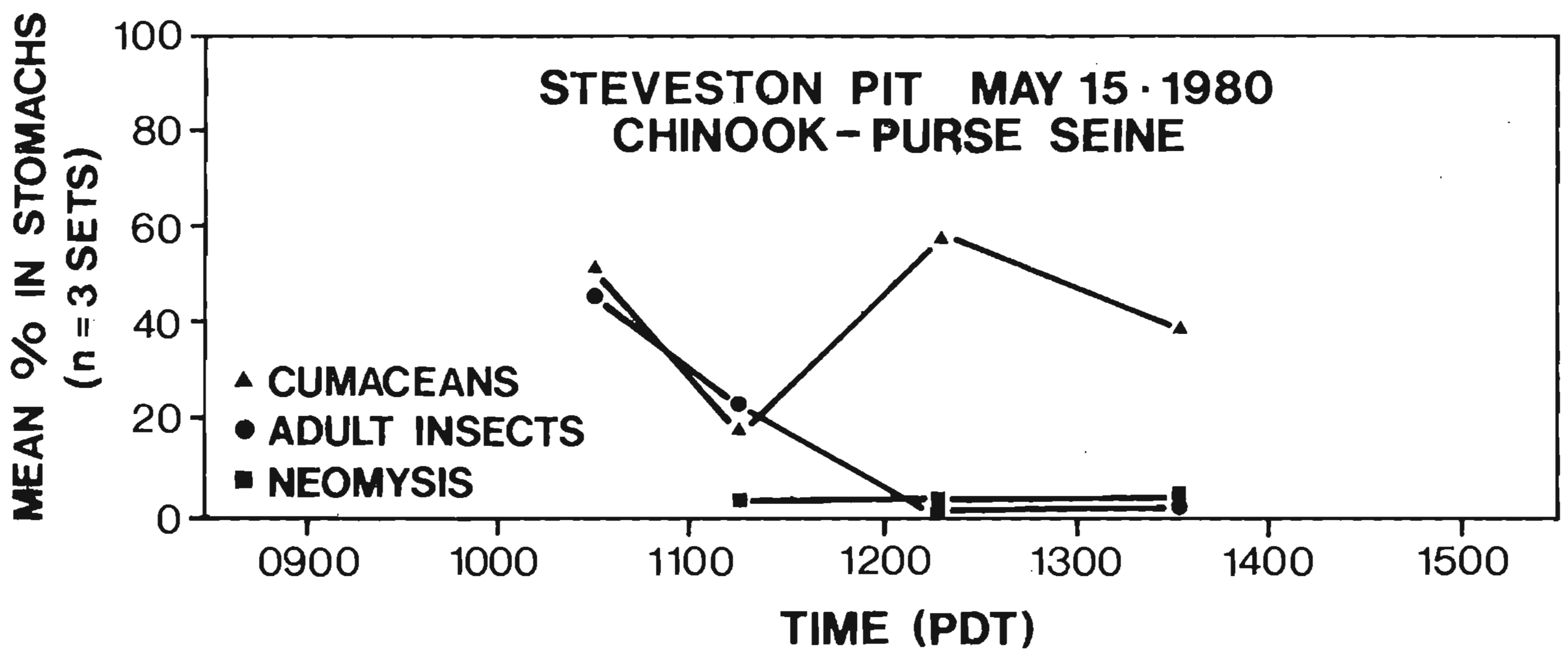

STEVESTON PIT MAY 14 · 1980
CHINOOK – PURSE SEINE
▲ CUMACEANS
● ADULT INSECTS
■ NEOMYSIS
MEAN % IN STOMACHS
(n = 3 SETS)
100
80
60
40
20
0
0900
1000
1100
1200
1300
1400
1500
TIME (PDT)

Fig. 7a.



STEVESTON PIT MAY 15 · 1980
CHINOOK - PURSE SEINE
MEAN % IN STOMACHS (n = 3 SETS)
100
80
60
40
20
0
▲ CUMACEANS
● ADULT INSECTS
■ NEOMYSIS
0900
1000
1100
1200
1300
1400
1500
TIME (PDT)

Fig. 7b.

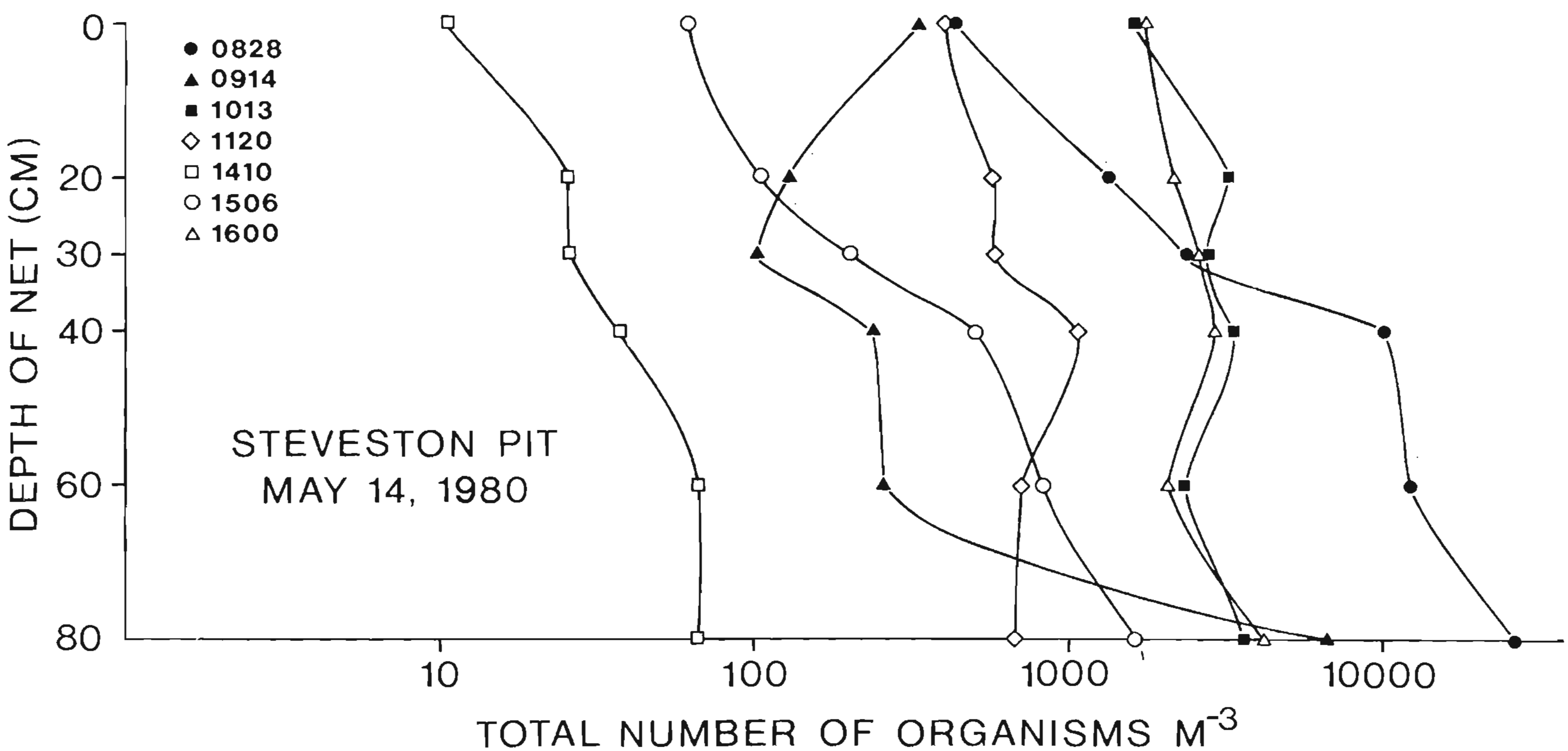
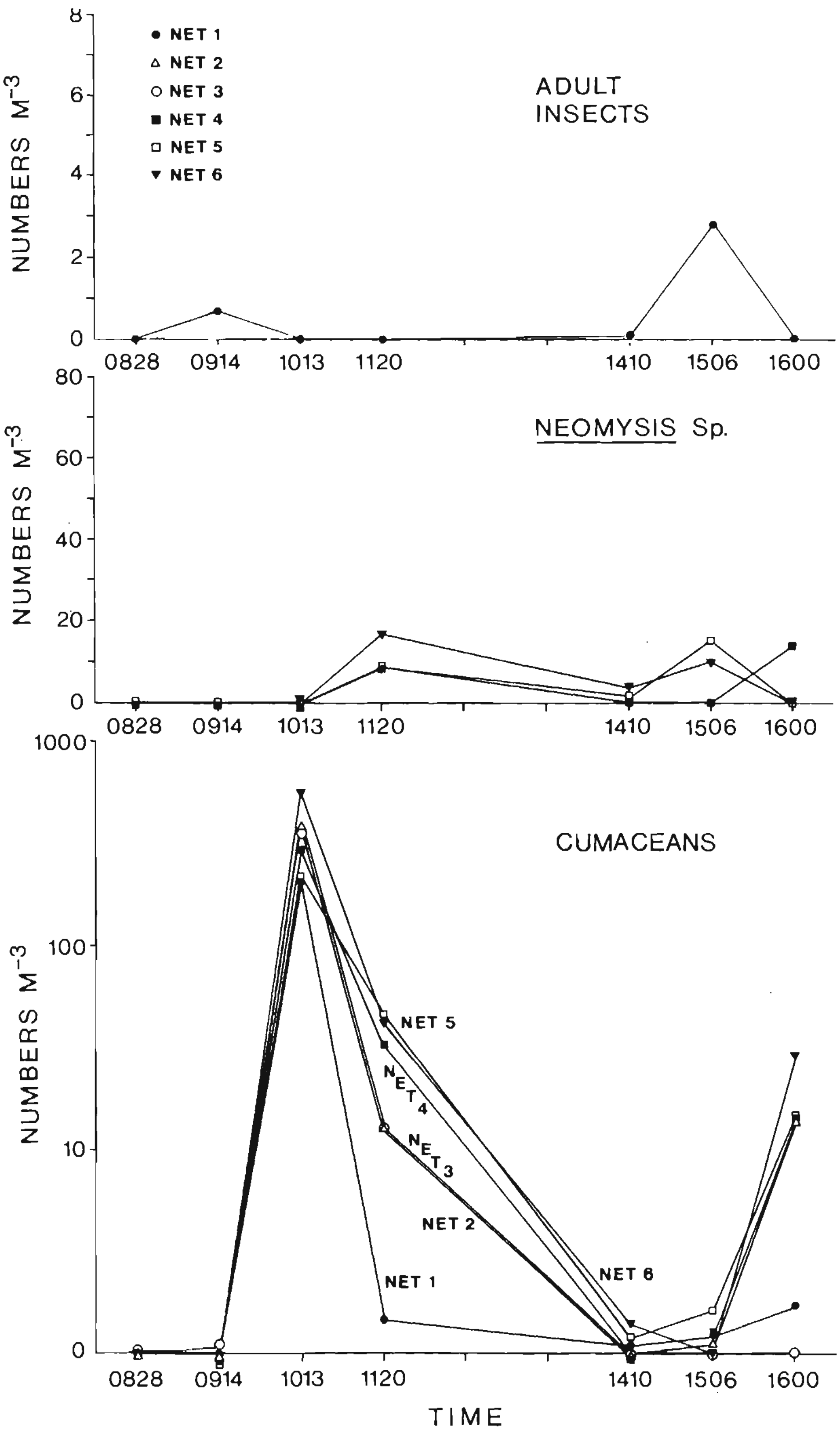

0828
0914
1013
1120
1410
1506
1600
STEVESTON PIT
MAY 14, 1980
DEPTH OF NET (CM)
0
20
30
40
60
80
10
100
1000
10000
TOTAL NUMBER OF ORGANISMS M-3

Fig. 8.



NET 1
NET 2
NET 3
NET 4
NET 5
NET 6
ADULT INSECTS
NEOMYSIS Sp.
CUMACEANS
NUMBERS M^-3
NET 5
NET 4
NET 3
NET 2
NET 1
NET 6
0828
0914
1013
1120
1410
1506
1600
TIME

Fig. 9.