Dredged Material Research Program

TECHNICAL REPORT D-77-30

AQUATIC DISPOSAL FIELD INVESTIGATIONS
COLUMBIA RIVER DISPOSAL SITE, OREGON

APPENDIX D: ZOOPLANKTON AND ICHTHYOPLANKTON STUDIES

by

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March 1978

Final Report

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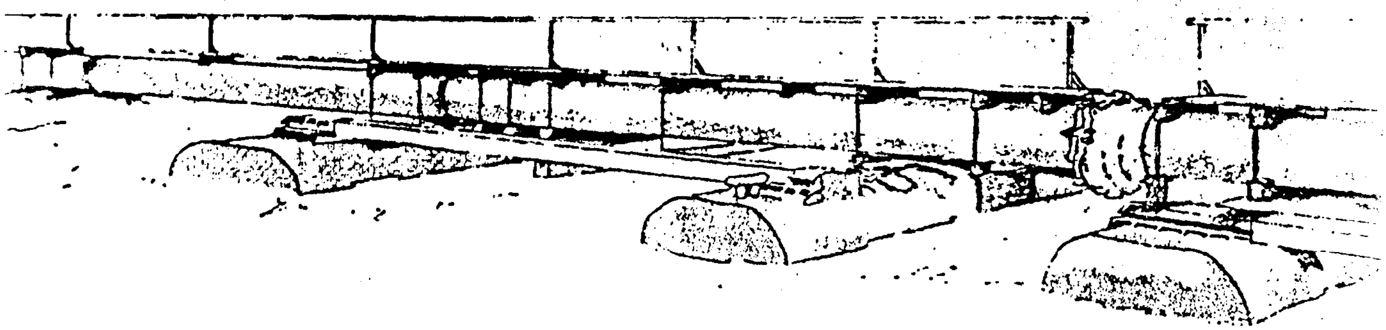

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

Under Contract Nos. DACW57-75-C-0155 and DACW57-76-C-0091
(DMRP Work Unit No. 1A07D)

Monitored by Environmental Effects Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

AQUATIC DISPOSAL FIELD INVESTIGATIONS
COLUMBIA RIVER DISPOSAL SITE, OREGON

APPENDIX A: Investigation of the Hydraulic Regime and Physical Nature of Bottom Sedimentation

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APPENDIX C: The Effects of Dredged Material Disposal on Benthic Assemblages

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Technical Report D-77-30

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
AQUATIC DISPOSAL FIELD INVESTIGATIONS, COLUMBIA RIVER DISPOSAL SITE, OREGON; APPENDIX D: ZOOPLANKTON AND ICHTHYOPLANKTON STUDIES

5. TYPE OF REPORT & PERIOD COVERED
Final Report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Robert L. Holton, Lawrence F. Small

8. CONTRACT OR GRANT NUMBER(s)
Contract Nos. DACW57-75-C-0155 and DACW57-76-C-0091

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Oregon State University
School of Oceanography
Corvallis, Oregon 97331

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
DMRP Work Unit No. 1A07D

11. CONTROLLING OFFICE NAME AND ADDRESS
Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

12. REPORT DATE
March 1978

13. NUMBER OF PAGES
46

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
U. S. Army Engineer Waterways Experiment Station
Environmental Effects Laboratory
P. O. Box 631, Vicksburg, Miss. 39180

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
This report was reproduced on microfiche and will be inclosed in an envelope attached inside the back cover of the main report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Columbia River	Fishes
Dredged material	Plankton
Dredged material disposal	Ichthyoplankton
Field investigations	Waste disposal sites
	Zooplankton

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A zooplankton and ichthyoplankton field research study was conducted in the vicinity of the mouth of the Columbia River to establish baseline planktonic conditions and to estimate the effect of open-water disposal of dredged material on the zooplankton and ichthyoplankton in the region. During the 1-1/2-year study, a total of 304 plankton samples were taken from bottom, oblique, and surface tows using 1-m (571 micron mesh) and 1/2-m (200 or

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SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. ABSTRACT (Continued).

110 micron mesh) nets. All ichthyoplankton samples collected were sorted and identified; however, due to time and funding constraints, only 50 percent of the zooplankton samples collected were sorted and identified.

The second objective, i.e., evaluation of the impact of dredged material on the local zooplankton population, was not achieved since the disposal of dredged material basically did not occur at the scheduled times. However, the data presented do provide new information on the zooplankton and ichthyoplankton seasonal distributions at the mouth of the Columbia River and therefore should provide useful information for further research in this region.

Larval and juvenile fish (6320 total) from eighteen families were taken during the study, with smelt being the most abundant group followed by anchovies, righteye flounders (pleuronectidae), codfishes (gadidae), and sculpins (cottidae). Ichthyoplankton abundances were highest in the winter-spring periods and lowest in August.

Calanus spp. dominated the copepod numbers throughout the year as did *Atylus tridens* among gammaridean amphipoda with 79.7 and 93.6 percent, respectively, of the totals. *Hyperoche medusarum* was the most abundant hyperid amphipod while *Diastylopsis dawsoni* was the most abundant cumacean. Decapod numbers were dominated by *Cancer magister*, pinnotheridae, crangonidae zoea, and miscellaneous natantia.

Both ichthyoplankton and zooplankton catch data suggest that summer disposal operations would minimize any dredged material disposal effects.

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DISCLAIMER

This report contains some general information regarding the spatial and temporal distribution of planktonic communities in the vicinity of the mouth of the Columbia River; however, it does not provide any useful data on the effects of dredged material disposal on these communities.

Inability to establish [illegible] [illegible]nktonic baseline information, insufficient time and personnel to examine all samples collected in detail, logistic problems associated with coordination of research vessel and hopper dredge schedules, and the general problems associated with sampling a highly variable component of the ecosystem were all factors which combined to invalidate the estimation of the effects of dredged material disposal. For these reasons this report has been microfiched and is attached to the main Columbia River Report.

PREFACE

This report presents the research conducted by the School of Oceanography, Oregon State University, under Contract Nos. DACW57-75-C-0155 and DACW57-76-C-0091 with the U. S. Army Engineer Waterways Experiment Station (WES), Environmental Effects Laboratory (EEL), Vicksburg, Mississippi. This work forms part of a multidisciplinary study conducted near the mouth of the Columbia River between October 1974 and May 1976 as part of the nationwide Dredged Material Research Program (DMRP).

This portion of the study, entitled "Zooplankton and Ichthyoplankton Studies," describes the planktonic composition and dynamics in and near areas of dredged material disposal. The research was conducted under the supervision of Drs. Robert L. Holton and Lawrence F. Small of Oregon State University.

The report comprises Work Unit 1A07D of the WES Environmental Impacts and Criteria Development Project, Dr. Robert M. Engler, Manager, EEL. The study was under the general supervision of Dr. John Harrison, Chief, EEL.

Directors of WES during the preparation of this report were COL G. H. Hilt, CE, and COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.304	metres
knots (international)	0.514	metres per second
gallons (U. S. liquid)	3.785	cubic decimetres
cubic yards	0.764	cubic metres
miles	1.609	kilometres

AQUATIC DISPOSAL FIELD INVESTIGATIONS

COLUMBIA RIVER DISPOSAL SITE, OREGON

APPENDIX D: ZOOPLANKTON AND ICHTHYOPLANKTON STUDIES

PART I: INTRODUCTION

Purpose and Scope

1. This study was conducted to establish a baseline of the zooplankton and ichthyoplankton present in the region at the mouth of the Columbia River and to determine the impact of the disposal of dredged material on the zooplankton of the region.

2. Such a baseline can be properly established only by a study of several years duration to determine the seasonal patterns of distribution as well as the year to year differences. Since this study was shortened from the original projection of 3 years to 1-1/2 years, it was impossible to obtain enough samples to clearly establish the baseline conditions. Also, the analysis of samples was severely limited since there was only one person to handle all of the zooplankton samples and it was not possible to examine all samples in detail.

3. The second objective, i.e., evaluation of the impact of dredged material on the local zooplankton population, was not achieved since the disposal of dredged material basically did not occur at the scheduled times.

4. The field sampling program consisted of six cruises between January and October 1975. A summary of the sampling is presented in Table D1. Each cruise is designated by a cruise number. For example, one of the cruises is labeled Y7506B. The first letter indicates the vessel used, Y indicating the R/V YAQUINA, F indicating the FORERUNNER, S indicating the SACAJAWEA, and C indicating the R/V CAYUSE. The first two numbers indicate the year, the next two the month. In the example cited above, the cruise was in June of 1975. The next letter indicates the number of cruises that vessel made that month. The case

cited above indicates that two cruises were made in June by the Yaquina.

Limitations of Study

5. The methods of sampling are described in Part II. The analysis of the samples required the sorting, counting, and identification of species by hand, which was a laborious process. Since adequate funds were not provided to complete this process, many samples that were taken could not be analyzed.

6. To establish a baseline for plankton in an oceanic area would require well over a year of sampling with adequate time and manpower to thoroughly analyze the samples. An adequate baseline could not be established due to funding and manpower constraints. However, some useful knowledge concerning plankton in the region is provided.

PART II: PROCEDURES

Sampling

7. A plankton pump and 1/2-m plankton net were proposed as possible sampling gear for zooplankton and ichthyoplankton. The plankton pump was suggested as a sampling device because of its ability to collect samples from discrete depths within the water column. The 1/2-m net was chosen as a more or less traditional sampling device with which the pump's effectiveness could be tested. Neither the plankton pump nor the 1/2-m net proved totally adequate devices with which to sample the various sizes of planktonic animals encountered. The low water volumes filtered (16.8 m^3/hour for the pump and 727 m^3/hour for the 1/2-m net) and the ability of some animals to avoid these samplers necessitated the use of a sampler which could filter larger volumes of water rapidly. A 1-m plankton net was chosen. This net filtered water at the rate of approximately 2909 m^3/hour. The pump system was discarded as a sampler since only relatively few, very small animals were effectively sampled by it.

8. A 1/2-m net of 200 μ mesh was maintained in the sampling program, but a second 1/2-m net of 110 μ mesh was acquired to more adequately sample animals missed by the 571 μ mesh of the 1-m net. This 110 μ mesh size was selected as being the smallest workable size as well as one capable of capturing the small larvae of bivalves. Because this newer net ripped or developed holes, it was not used throughout an entire cruise until the August Y7508D cruise.

9. A 1/2-m and/or a 1-m plankton net were used to collect all samples reported. Surface, oblique, and bottom tows were made at each station by towing the 1/2-m net (200 μ or 110 μ mesh) for 7.5 minutes at 3.7 km/hour (2 knots) and the 1-m net (571 μ mesh) for 15 minutes at 3.7 km/hour. Surface tows were made by towing the net approximately 1 m below the surface. Oblique tows were made by lowering the net until the weight (113.6 kg attached 2 m below the net) bumped bottom, retrieving 1 m of cable, and towing for 1 minute at that depth. At the end of

each succeeding minute, 1/15 (1-m net) or 1/7.5 (1/2-m net) of the cable was retrieved. Thus, net retrieval was made in a series of small steps. Bottom tows were made by lowering the net in the same manner as for oblique tows and continuing to tow at the deepest position, approximately 3 m above the bottom in calm seas. In order to keep the net from striking the bottom or breaking the surface, when seas became rougher, the amount of cable out had to be decreased for bottom and oblique tows and increased for surface tows. All tows were retrieved and set at approximately 90 m/minute. Maximum cable out rarely exceeded 45 m; thus, 60 seconds or less of total set and retrieval time were usually needed.

10. The first tow at each station originated at the station location and movement was away from the station at a heading which was best suited to the prevailing wind, current, and obstacle (fishing boats and crab pot buoys) pattern. The second tow was made on a heading 180° relative to the initial heading. The third tow again originated at the station location on the initial heading. A position fix was made at the beginning and end of each tow with a Del Norte Navigation System or LORAN. Thus, tow tracks were plottable even when strong currents and winds deflected the tow tracks from the ship's heading.

11. A flowmeter suspended in the mouth of the nets measured the volume of water filtered by each tow. All planktonic samples were washed from the nets with running seawater, concentrated, and preserved in formalin. During the January (Y7501B), March (F7503A), June (Y7506B), and July (Y7507A) cruises, salinity and temperature data were collected after each bottom tow from the bottom to the surface at 5-m intervals. Other salinity and temperature data were collected and reported as part of the chemical studies of the Columbia River project.

12. Plankton samples were taken only with the 571 μ mesh 1-m net in January and March 1975. Eight and six stations (Figure D1), respectively, located along the 30-m contour approximately 5.5 km off the mouth of the Columbia River were sampled. In June two of these

stations were sampled over 30-hour periods to study diel and tidal variations. Series of surface, oblique, and bottom 1-m net tows were taken repeatedly with a series of 1/2-m net tows being taken after two series of 1-m net tows.

13. Between 7 and 10 July 1975 sampling of zooplankton and ichthyoplankton was scheduled at an experimental dredged material disposal site. This site had been established at 46°11'06"N, 124°06'00"W and marked with a buoy. Dumping was scheduled to begin at 2400 on 8 July 1975 and continue until 0600 on 27 August 1975. During this period approximately one million cubic yards (1/2 of the average yearly disposal) was scheduled to be dredged from the Columbia River bar and dumped on the experimental site. The objective was to study the plankton populations existing prior to the initiation of and during the dumping of dredged materials in order to observe any effects which dredged materials might have had on those populations. A 30-hour series of tows prior to and another 30-hour series during continuous dumps of dredged materials were scheduled.

14. The "pre-dump" 30-hour series of samples was collected on schedule. However, the second crucial 30-hour series completely failed to meet the sampling objectives. Due to start dumping at 2400 on 8 July, the dredge ship CHESTER A. HARDING delivered its first and last load to the experimental dump site at approximately 1215 on 9 July. Even if continuous dumping had started at 1215 on 9 July, 12.25 hours behind schedule, there would have been insufficient time to complete a 30-hour series of samples within the time schedule imposed by the availability of the research vessel. Due to a reported broken drag arm aboard the HARDING, no subsequent dumps were made until 0200 on 10 July when the dredge ship BIDDLE made a dump, 13.75 hours after the initial dump by the HARDING. The BIDDLE dredged material from outside the mouth of the Columbia River before making four other dumps which occurred at 0350, 0600, 0800, and 1000 on 10 July. This was the only series of consecutive dumps made, and they spanned only 8 hours.

15. During its passes around the buoy, the dumping dredge ship was closely followed (200-400 m) by the research vessel as tows were

made. The research vessel continued to tow through the observed area of dumping after departure of the dredge ship. No dredged materials were brought up in the nets until 0600 on 10 July. All subsequent tows contained sediment, even in tows made 30-45 minutes after the departure of the dredge ship. No unusual current conditions were observed in the area during the sampling period.

16. U. S. Army Engineer Waterways Experiment Station (WES) personnel requested that an attempt be made to collect some replicate plankton samples from the study area; therefore, a special cruise was arranged on the R/V SACAJAWEA. On 4 August, 3 replicate tows at bottom and surface positions were made with both the 1-m net and the 1/2-m net. It was not possible to collect oblique samples since the vessel lacked a cable metering device. Not a single larval or juvenile fish was taken during this daylight sampling program.

17. During the 4 August cruise, the dredge ships BIDDLE (at 0530) and HARDING (at 1430) were seen to be actively dredging near the mouth of Youngs Bay. It was not seen where these vessels were dumping their dredged materials; however, neither vessel was seen outside the mouth of the Columbia River or at the experimental dump site.

18. Because dumping of dredged materials at the experimental dump site was to have been continuous until 0600 on 27 August 1975, a cruise was made 24-28 August 1975. Two 30-hour series of samples were planned; one during continuous dumping prior to the end of dumping at 0600 on 27 August, and the other after the conclusion of dumping. The cruise ship arrived at the experimental dump site at 0400 on 25 August and no dredge ships were observed in the area. The first 30-hour series was begun at 2400 on 25 August. At 0830 on 26 August, it was decided to consider this series of samples as equivalent to the planned second 30-hour series since no dredge ship had appeared. This decision was radioed to the HARDING. At approximately 1400 on 26 August, the HARDING made the first dump on the experimental dump site. At 1600, the HARDING made its second and last dump. Sampling was terminated at 0430 on 27 August because of bad weather.

19. As a result of the apparent lack of dumping by the dredge

vessels and the low abundance of fish larvae present during July and August, no conclusions can be drawn as to the effects of dredged material dumping on fish larvae populations. Although zooplankton was more abundant, the same lack of dumping prevented gathering of useful data.

20. Samples were again collected over a 30-hour period on a cruise between 20 and 23 October 1975 and at Anchor Station 2 (46°13'N, 124° 10'W) over a 12-hour period. This was the last cruise in the sampling program.

Sorting and Classifying

21. A total of 340 plankton samples were collected during the study (Table D1). Each was brought back to the laboratory where all were transferred to 5% formalin and buffered to pH 7. Each sample was completely sorted for fish larvae and for larger invertebrate animals such as mysids, jellyfish, and amphipods as well as for smaller larval decapods. Each major group was counted and placed in a separate glass vial or jar and preserved with 5% buffered formalin. Within a taxon at the primary level of sorting, the larval, juvenile, and adult forms were not distinguished. Subsequently, all the animals sorted from January Y7501B samples and from March F7503A samples from Stations 1-3 were identified as to species and stage of development. Only animals from 5 selected oblique 1-m net samples taken at Station 2 on the June Y7506B cruise; 6 oblique 1-m net samples taken at Station 2 on the August Y7508D cruise; and 4 oblique 1-m net and 2 oblique 1/2-m net samples taken at Station 2 and 1 oblique 1-m net sample at Anchor Station 2 on the October Y7510C cruise were identified as to species. Only animals from selected oblique samples from the June Y7506B, August Y7508D, and October Y7510C cruises were identified as to species and stage of development. These samples were selected from each of the three cruises on the basis of their equal distribution throughout a 30-hour sampling period at the experimental dump site (Station 2). Each group of samples was spaced six hours apart which roughly

corresponded to a tide, i.e. high high tide.

22. Smaller animals such as copepods and their nauplii were estimated by means of five 1-ml aliquots taken from a measured volume. These aliquots were then averaged and the number thus obtained was multiplied by the measured volume to obtain an estimate for the total sample. Since limited time precluded analysis of every sample, the total number was reduced. From four of each of ten surface, bottom, and oblique 1-m net samples from the two 30-hour stations, five aliquots were taken, averaged and then averaged across the four. This number was then multiplied by the measured volume of the six remaining samples in each category. Similarly aliquots were drawn from two of five 1/2-m net samples, averaged and multiplied by the settled volume in the other three. Thus, 60% of the copepod counts from each of the 30-hour stations were calculated numbers.

23. On the June 1975 cruise an effort was made to conduct a shipboard laboratory study on the effect of a series of trace metals on primary productivity. The equipment and methods described in the chemical report of the Columbia River project were used for measuring primary productivity. The shipboard work progressed fine; however, it was not possible to make the required ^{14}C measurements in the laboratory because the fluor provided by the supplier was contaminated.

24. A proposed study of the taxonomy of certain species of fish by raising larvae in the laboratory was not conducted due to the shortened research period.

PART III: RESULTS AND DISCUSSION

25. All samples collected with the 1-m net were sorted and analyzed for ichthyoplankton. Larval and juvenile fish (6320 total) from eighteen families were taken during the study (Table D2). Smelt was the most abundant group of fish taken (Table D3). Larval and juvenile abundances were highest in the winter-spring period (Table D4). With the exception of two samples from the October Y7510C cruise, only 1-m net samples were used to identify invertebrate species. The animals were counted and identified as to species and stage of development. The percentages each major species represented in its taxonomic group were calculated for each cruise (Tables D5-10).

26. *Calanus* spp. clearly dominated copepod numbers throughout the year (Table D5) as did *Atylus tridens* among gammaridean Amphipoda (Table D9) with 79.7% and 93.6%, respectively, of the totals. *Hyperoche medusarum* was the most abundant hyperid amphipod (Table D8) while *Diastylopsis dawsoni* was the most numerous cumacean (Table D7). Among the Mysidacea, *Acanthomysis macropsis* and *Neomysis kadiakensis* were of nearly equal occurrence, but seasonal dominance varied (Table D6).

27. As zoea, *Cancer magister* larvae were the most abundant decapod larvae in the January samples (85%), but as megalopa they represented only 1% of the total decapods in the June Y7506B cruise (Table D10). However, the presence of this commercially important species in its sensitive megalopa stage during the initial summer dredging operations is an important consideration.

28. The Pinnotheridae, the pea crabs, were the most abundant decapod in June followed by the crangonid shrimp. Although representing 50% of the August samples, larval shrimp, especially Crangonidae, reached their peak abundance in March (Figure D2).

29. In June the first of two 30-hour samplings was conducted at Station 2, near the experimental dump site, and the other at Station 4 near buoy 1. Station 2 is in a cyclonic gyre only slightly influenced by the river and tidal currents. Throughout the 30-hour sampling period readings revealed little change in bottom salinity (32.6 -

33.8%). Only slight changes occurred at the surface (25.0 - 31.4%) with the lowest at 2122 prior to high high tide at 2302 (Table D11), and the highest between low high tide (1220) and high low tide (1729) at 1245 (Figure D3).

30. Station 4 near the mouth of the river is more influenced by tidal currents and river discharge than Station 2. Here readings indicate a far greater range in surface salinity (5.5 - 26.6%), but still little change at the bottom (32.5 - 33.1%). Peaks in surface salinity occurred at 1300, 0030, and 1046, with the lowest values at 0842, 2045, and 0848 (Figure D4). The only tide to correspond to a salinity maximum or minimum was the high high tide at 0037 on 23 June. Measurements indicated that currents at maximum ebb were 6 knots while those prior to high low tide were 3 knots. (No current data were obtained for Station 2.)

31. Because these stations are of different character, the tidal and diel behavior of each major taxon appear somewhat dissimilar at the two stations. Pelagic and planktonic animals did not show any discernible cycle as sample variability alone could account for many of the differences in the data. Animals of benthic origin, however, seemed to demonstrate a tendency toward nocturnal activity. A diel pattern was most clearly shown by the Mysidacea (Figures D5 and D6) and Cumacea (Figures D7 and D8) at Station 2. In the 1-m net samples at Station 4 the Mysidacea (Figure D9) showed a similar pattern with two exceptions. A peak of 21.5/1000 m^3 at 1545 in the oblique sample and a primary peak of 196/1000 m^3 at 0654 in the bottom sample occurred. Cumacea (Figure D11), on the other hand, showed little activity at Station 4 except for an enormously high density in the bottom sample at 0100 near high high tide on 23 June. The 1/2-m net samples also revealed high densities near the high high tide for the Mysidacea as well as the Cumacea (Figures D10 and D12). Although of far less density, Isopoda (36.7/1000 m^3) (Figure D13) and Polychaeta (12.3/1000 m^3) (Figure D14) were also more numerous at 0100 in the bottom 1-m net samples.

32. The diel cycles of some mysidacea have been documented by Enright and Hamner.[1] According to them, an *Archeomysis* sp., revealed

no apparent migratory pattern. In the June samples of the present study A. *grebnitzkii*, comprised 5.7% of the totals (Table D6). They found that *Acanthomysis macropsis*, an animal comprising 10.9% of the June samples, had a "light active" pattern. This pattern could explain their dominance in the daylight March samples. These two mysids may be responsible for some of the daylight activity seen at the 30-hour stations. The main day-night pattern revealed in this study is probably characteristic of *Neomysis kadiakensis*, the major mysid species in June (50.5%).

33. The data obtained by Enright and Hamner[1] in a laboratory study also suggested a "dark active" endogenous pattern for an isopod, *Exosphaeroma* sp., and a cumacean, *Cyclaspis* sp. Jones[2] states that coastal species of cumaceans frequently swim up from the bottom at night. Some polychaetes have also been known to swim up into the water column at night for feeding purposes or, as epitokes, to gather for reproductive purposes.[3] Many of the identical polychaetes were epitokes.

34. Gammaridean Amphipoda (Figure D15) also peaked at 0100 (512/1000 m^3) at Station 4 as did the polychaetes, cumaceans, isopods, and mysids. In addition, gammarids showed some surface activity (35.9/1000 m^3) at night. The numbers, however, are not comparable to Station 2 where peak high tide nocturnal surface densities were 111/1000 m^3 (Figure D16). Densities in the bottom samples also peaked near high high tide. Bottom and oblique data also revealed some mid-afternoon activity at 1450 and 1530, respectively. These peaks occurred after a fall in surface salinity at 1420 (Figure D3). Station 2 1/2-m net bottom samples (Figure D17) revealed an afternoon peak at 1309 which could be part of the peak seen at 1450 for the 1-m net (Figure D16). The Station 4 1/2-m net bottom samples peaked at 1056, 2254, and 1110 (Figure D18). These times correspond fairly well with the salinity surface maximums at 1045, 0030, and 1056 (Figure D4).

35. Two papers (Preece[4]; Fincham[5]) suggest that some gammarid amphipods have activity peaks closely associated with either a nocturnal high or high slack water. Wildish[6] found a primary tidal peak and

a secondary tidal peak similar to those in Station 2 data (Figure D16). This activity, as Naylor[7] suggests could be an indication of a bi-component rhythm, one of diel frequency with peak activity during darkness and one of tidal frequency with peak activity at the time of high tide. A lag time of the secondary peak behind the diurnal high tide, which was observed in Station 2 data, was also noted by Jones et al.[8] Station 4 data reveal (Figure D15) only the one nocturnal peak. Activity there may have been suppressed by a combination of daylight and strong currents. One subtidal amphipod was unable to swim in currents in excess of 0.44 knots.[8] *Atylus tridens* comprising over 90% of the gammaridean samples (see Table D9) could be a stronger swimmer, but its activity may still be suppressed by the strong currents present at Station 4. Only when light and currents were negligible at a nocturnal high slack water were the amphipods found in the water column in any great densities.

36. However, without coincident biological and physical data and subsequent concurrent laboratory tests, it is impossible to accurately predict activity of a particular animal at a given time. Comparisons between stations and within stations at a different time of day and for different months should be made with extreme caution. For example, March samples were taken exclusively in daylight; therefore, in view of their nocturnal activities, cumaceans are not necessarily nonexistent in March. Tidal and coastal currents, species succession, and animal behavior will also affect any comparison.

37. There are other limitations. The fish-retaining ability of a 1-m net of 571 μ mesh and a 1/2-m net of either 200 μ or 110 μ mesh is not comparable. Avoidance of the 1/2-m net by larger, more mobile animals is greater than for the 1-m net. A 1-m net of 571 μ mesh cannot catch naupliar Copepoda, copepodites, or even most of the adult copepods. *Calanus* sp. cannot be considered, therefore, the dominant copepod genus although it was clearly dominant in the 1-m net samples. The absence of polychaete, cirriped, or bivalve larva from the 1-m net or even the 200 μ mesh 1/2-m net samples cannot necessarily be considered an absence from the water column. The sampling gear merely

demonstrated an inability to sample in the smaller size classes.

38. Because sample variability was not measured, densities cannot be considered absolute. In some cases estimates of animals per unit volume vary widely between the 1-m and 1/2-m nets. Smaller nets usually catch fewer species in fewer numbers than do larger nets. In some instances densities for the 1/2-m nets were much greater than those for the 1-m net. This discrepancy might be explained by patchiness, a term used to describe non-random grouping. If a swarm of animals is small enough to be completely sampled by both 1/2- and 1-m nets, the estimate per volume will be higher in the smaller net. There is no way with the data obtained in this study, however, to distinguish the effects of patchiness or sample variability.

PART IV: CONCLUSIONS

39. The ichthyoplankton studies showed that over 60% of the larval and juvenile catch was composed of smelts of the Family Osmeridae with anchovies of the Family Engraulidae making up 12% of the catch (Table D3). Both of these families are thought to be very important as food chain items for larger fish, including salmon. Therefore, there is a great interest in the continued abundance of these fish.

40. As expected, the ichthyoplankton catches showed a great variability in time. Catches were abundant in January, reached a peak in March, and reached a low point in August (Table D4). This implies that any effects of the disposal of dredged material might be minimized by disposal in late summer.

41. The zooplankton data show an abundance of the larval stages on the important crab, *Cancer magister*, for January and March (Figure D2). Again this might indicate that summer disposal would be an advantage.

42. Most of the zooplankton species are found in the water column during the night and are nearer the bottom during the day (Figures D4-18). They should be less likely to be influenced by dredged material when they are dispersed throughout the water column.

43. Due to the shortness of the sampling program and the lack of funds for analysis of the samples, it was not possible to develop an adequate baseline of plankton conditions in this area. However, the results obtained in this study should prove helpful in future research.

44. The second objective, i.e. assessment of the impact of dredging on the plankton communities, was not achieved. As previously explained, the lack of dumping when the research vessel was on site prevented such an evaluation. Also, the added labor which would have been required to complete sample analysis was not available.

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Table D1

List of Samples Taken and Analyzed for Plankton Baseline

Month (Cruise No.)	Number of Samples	Surface gal	Surface qts	Bottom gal	Bottom qts	Oblique gal	Oblique qts	Total gal	Total qts	Percent of Samples Analyz Ichthyoplankton	Zooplank
January (Y7501B)	24	-	10	-	8	-	8	-	26	100	100
March (F7503A)	18	-	6	-	6	-	6	-	18	100	100
June (Y7506B)	114	5	36	31	51	19	48	55	135	100	100
July (Y7507A)	77	8	25	10	29	9	25	27	79	100	0
August (S7508A)	12	1	5	5	4	-	-	6	9	100	0
(Y7508D)	48	1	15	7	15	8	12	16	42	100	10
October (Y7510C)	47	7	12	15	13	13	9	35	34	100	10
TOTAL	340	22	109	68	126	49	108	139	343		

Table D2

List of Families Represented in the Larval and Juvenile Catch of the Columbia River Mouth

Family	Common Name
Agonidae	poacher
Ammodytidae	sand lance
Bathymasteridae	ronquil
Clupeidae	herring
Cottidae	sculpin
Cyclopteridae	lumpfish and snailfish
Cyprinidae	minnow and carp
Engraulidae	anchovy
Gadidae	codfish
Gasterosteidae	stickleback
Hexagrammidae	greenling
Myctophidae	lanternfish
Osmeridae	smelt
Pholidae	gunnel
Pleuronectidae	righteye flounder
Salmonidae	trout
Scorpaenidae	scorpionfish
Stichaeidae	prickleback

Composition of Total Larval and Juvenile Catch off the Columbia River Mouth

Family	% Larval and Juveniles Collected
Osmeridae (smelt)	60.6
Engraulidae (anchovy)	12.1
Pleuronectidae (righteye flounder)	8.9
Gadidae (codfish)	8.0
Cottidae (sculpin)	4.4
Ammodytidae (sandlance)	2.3
Cyclopteridae (snailfish)	1.5
Agonidae (poacher)	1.0
Others	1.2
TOTAL	100.0

Table D.

Abundance of Larval and Juvenile Fishes at the Mouth of the Columbia River, 1975

Date	No. of Samples	No. Larvae and Juveniles ÷ Water Volume Filtered (1000 m^3)
22-25 January	30	48.6
11-13 March	18	106.9
20-24 June	115	10.1
8-10 July	44	7.0
25-27 August	34	0.4
20-22 October	35	1.8

Table D5

Percentages of Major Species in the Order Copepoda from meter net samples

COPEPODA	January Y7501B	March F7503A	June Y7506B	August Y7508D	October Y7510C	Average
Calanus spp.	98.6	94.3	93.5	70.2	42.0	79.7
Acartia longiremis	0.0	2.3	2.6	1.1	10.6	3.3
Acartia clausi	0.0	1.7	0.5	0.2	17.5	4.0
Centropages mcmurrichi	0.0	1.7	0.0	27.1	13.7	8.5
Metridia spp.	1.1	0.0	3.1	0.0	1.9	1.2
Tortanus discaudatus	0.1	0.0	0.0	0.0	13.4	2.7
other species	0.2	0.0	0.3	1.4	0.9	0.6

Table D6

Percentages of Major Species in the Order Mysidacea

MYSIDACEA	January Y7501B	March F7503A	June Y7506B	August Y7508D	October Y7510C	Average
Archeomysis grebnitzkii	16.7	0.0	5.7	49.3	0.7	14.5
Acanthomysis macropsis	19.2	79.5	10.9	16.5	38.3	32.9
Acanthomysis nephrothalma	<0.1	0.0	27.9	0.0	4.5	6.5
Neomysis kadiakensis	17.6	2.3	50.5	34.2	52.4	31.4
Neomysis Sp.	15.7	[illegible]	[illegible]	0.0	0.3	3.2
unidentified juveniles	30.8	18.2	5.0	0.0	3.8	11.6

Table D7

Percentages of Major Species in the Order Cumacea

CUMACEA	January Y7501B	March F7503A	June Y7506B	August Y7508D	October Y7510C	Average
Colourostylis occidentalis	47.0	0.0	1.2	1.4	2.5	10.4
Diastylopsis dawsoni	45.0	0.0	81.6	69.4	46.9	48.6
Mesolamprops sp.	8.0	0.0	12.7	12.5	1.2	6.9
Unidentified Cumacea	0.0	0.0	4.5	16.7	49.4	14.1

Table D8

Percentages of Major Species in the Order Amphipoda, Suborder Hyperidae

HYPERIDEA	January Y7501B	March F7503A	June Y7506B	August Y7508D	October Y7510C	Average
Hyperia medusarum	0.0	0.0	0.0	5.0	27.0	6.4
Hyperoche medusarum	2.8	80.0	90.0	85.0	37.0	60.0
Parathemisto pacifica	86.0	0.0	5.0	5.0	11.0	21.4
Other Hyperids Hyperids	2.7	5.0	2.5	0.0	1.0	2.2
Unidentified juveniles	8.5	15.0	2.5	5.0	24.0	11.0

Table D9

Percentages of Major Species in the Order Amphipoda, Suborder Gammaridea

GAMMARIDEA	January Y7501B	March F7503A	June Y7506B	August Y7508D	October Y7510C	Average
Atylus tridens	98.0	99.0	94.0	99.7	77.3	93.6
Monoculodes spp.	0.3	0.0	2.6	0.0	21.2	4.8
Ischyrocerus pelagops	0.3	0.0	3.0	0.3	0.0	0.7
Other Gammaridea	1.4	1.0	0.4	0.0	1.5	0.9

Table D10

Percentages of Major Species in the Order Decapoda

DECAPODA	January Y7501B	March F7503A	June Y7506B	August Y7508D	October Y7510C	Average
Cancer magister	85.3	35.4	1.1	0.0	0.0	24.4
Cancer sp.	3.6	2.1	1.6	16.0	1.6	5.0
Pinnotheridae	0.4	0.9	34.2	0.0	40.2	15.1
Other Brachyura	4.4	0.1	6.9	2.3	0.8	2.9
Callinassidae	2.8	4.6	10.0	17.7	10.7	9.2
Paguridae	1.4	8.0	4.4	5.0	14.7	6.7
Porcellanidae	0.9	0.0	0.0	0.3	3.3	0.9
Crangonidae zoea	0.7	43.5	24.8	6.3	3.3	15.7
Crangonidae	0.1	0.0	4.2	0.7	5.7	2.1
Other Natantia	0.5	5.4	13.0	51.7	19.7	18.1

Table D11

Tide Table for the Columbia River Entrance (North Jetty) for the June Y7506B Cruise

JUNE		HIGH TIDES		LOW TIDES	
Date	Day	Time	Feet	Time	Feet
20	Fri	HHT 2302	8.6	HLT 1640	1.8
21	Sat	LHT 1220	6.1	HLT 0541	-1.6
		HHT 2352	8.6	LLT 1729	2.0
22	Sun	LHT 1312	6.3	LLT 0629	-1.9
		--	--	HLT 1841	2.0
23	Mon	HHT 0037	8.5	LLT 0735	-2.0
		LHT 1358	6.4	HLT 1930	2.1
24	Tues	HHT 0120	8.3	LLT 0817	-1.9

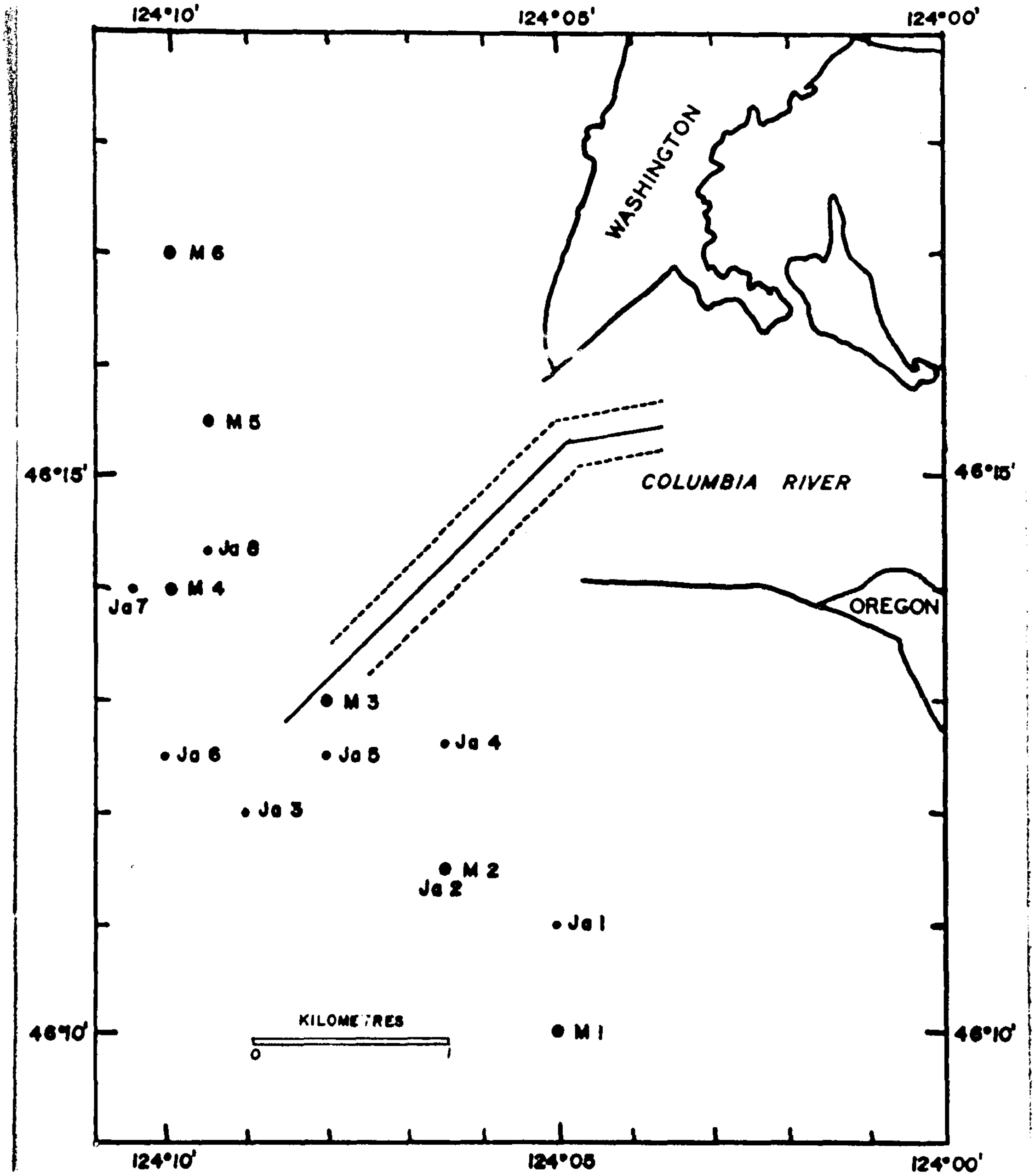

Figure D1. Location of the stations sampled on the January(Y7501B) and March(F7503A) cruises

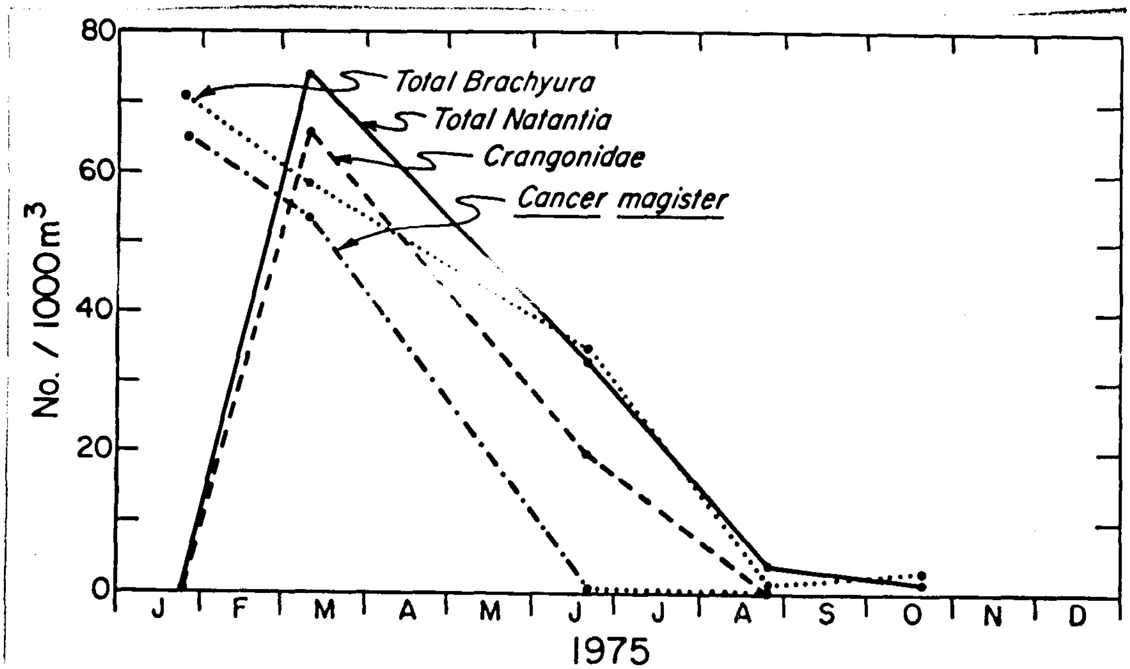

Figure D2. Seasonal abundance of shrimp and crab larvae taken in 1975

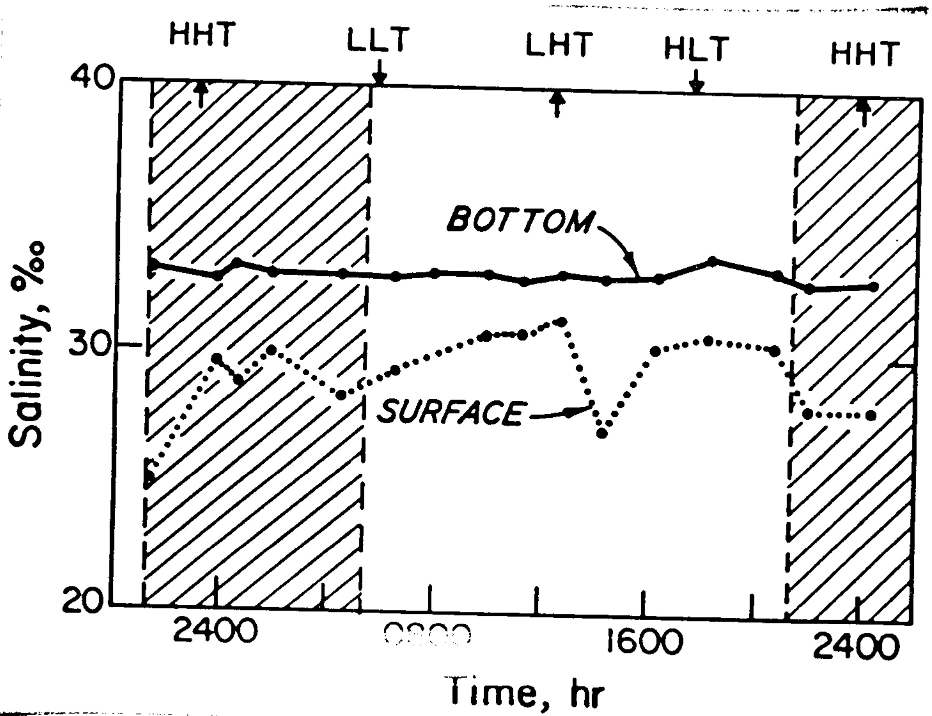

Figure D3. Surface and bottom salinity at Station 2 on 20 and 21 June 1975

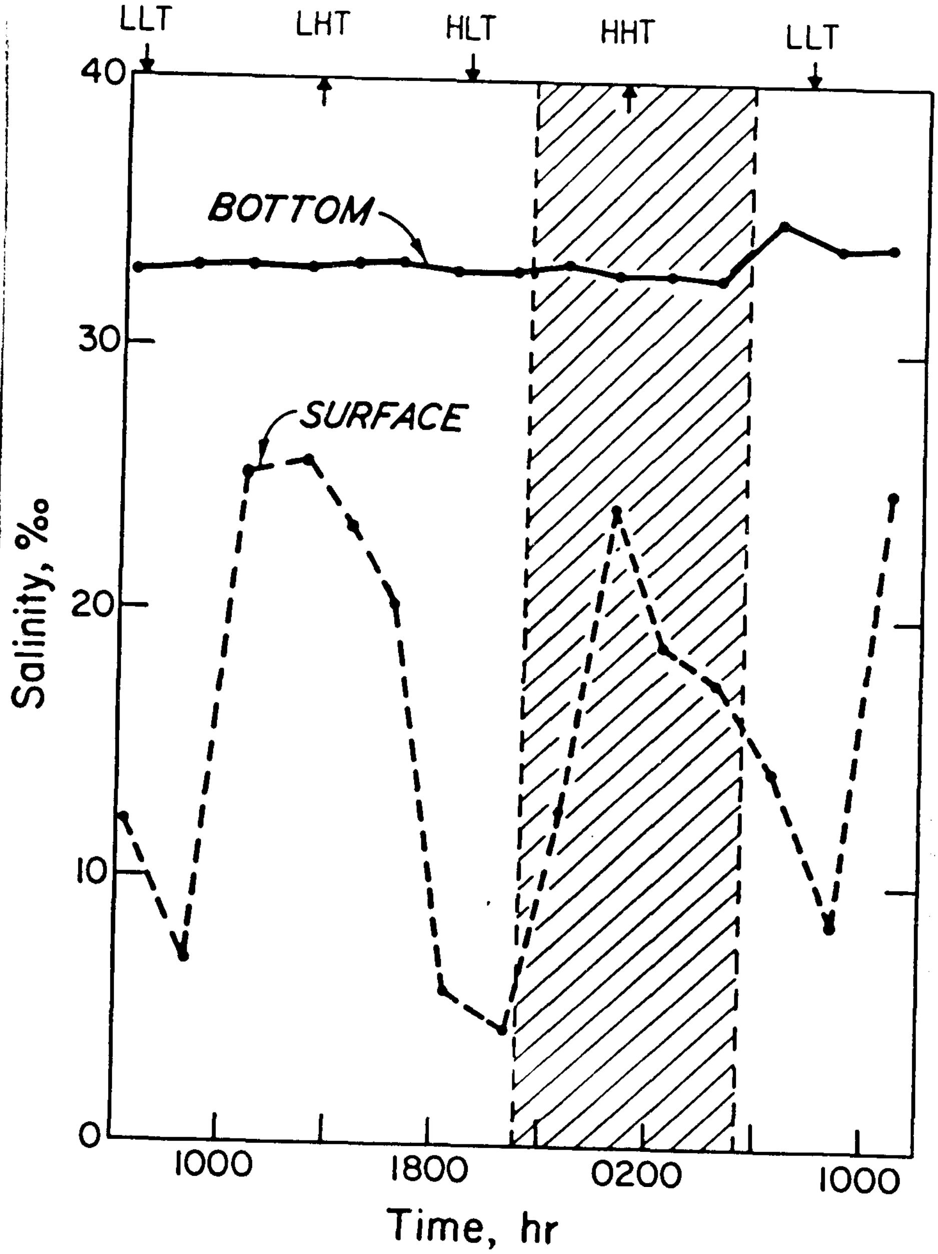

Figure D4. Surface and bottom salinity at Station 4 on 22 and 23 June 1975

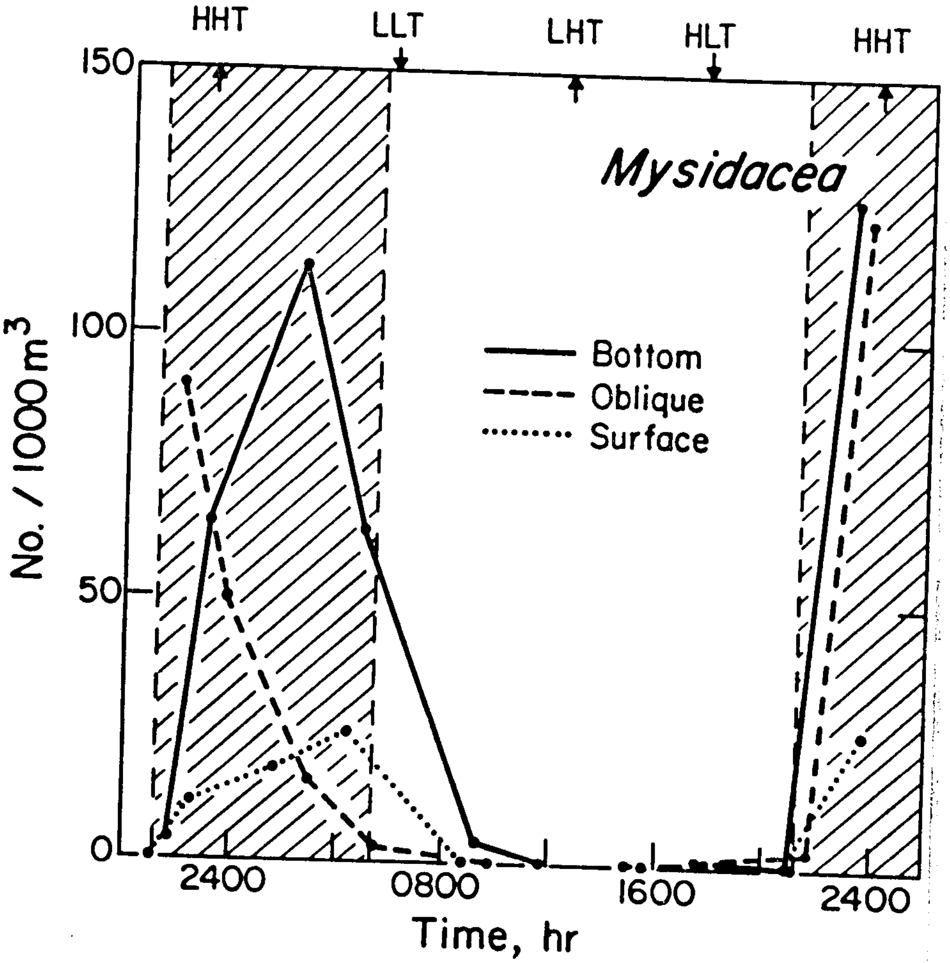

Figure D5. Mysidacea from surface, bottom, and oblique 1-m net tows at Station 2 on 20 and 21 June 1975

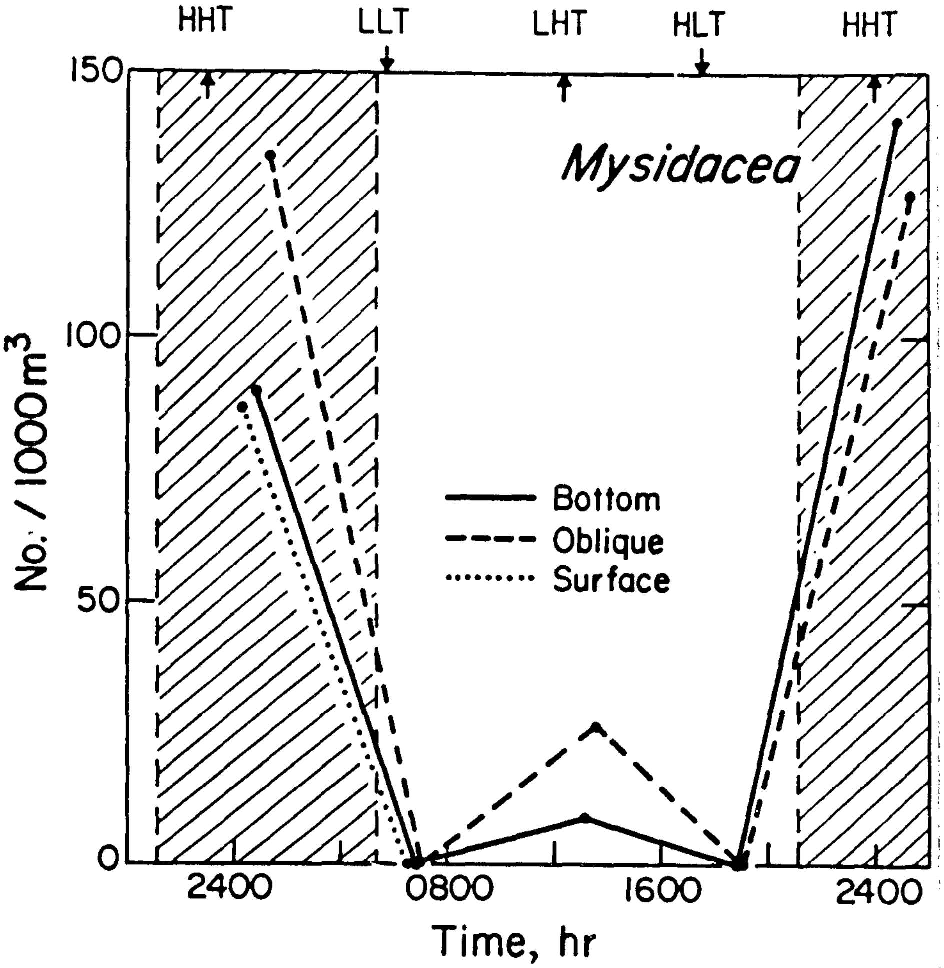

Figure D6. Mysidacea from surface, bottom, and oblique 1/2-m net tows at Station 2 on 20 and 21 June 1975

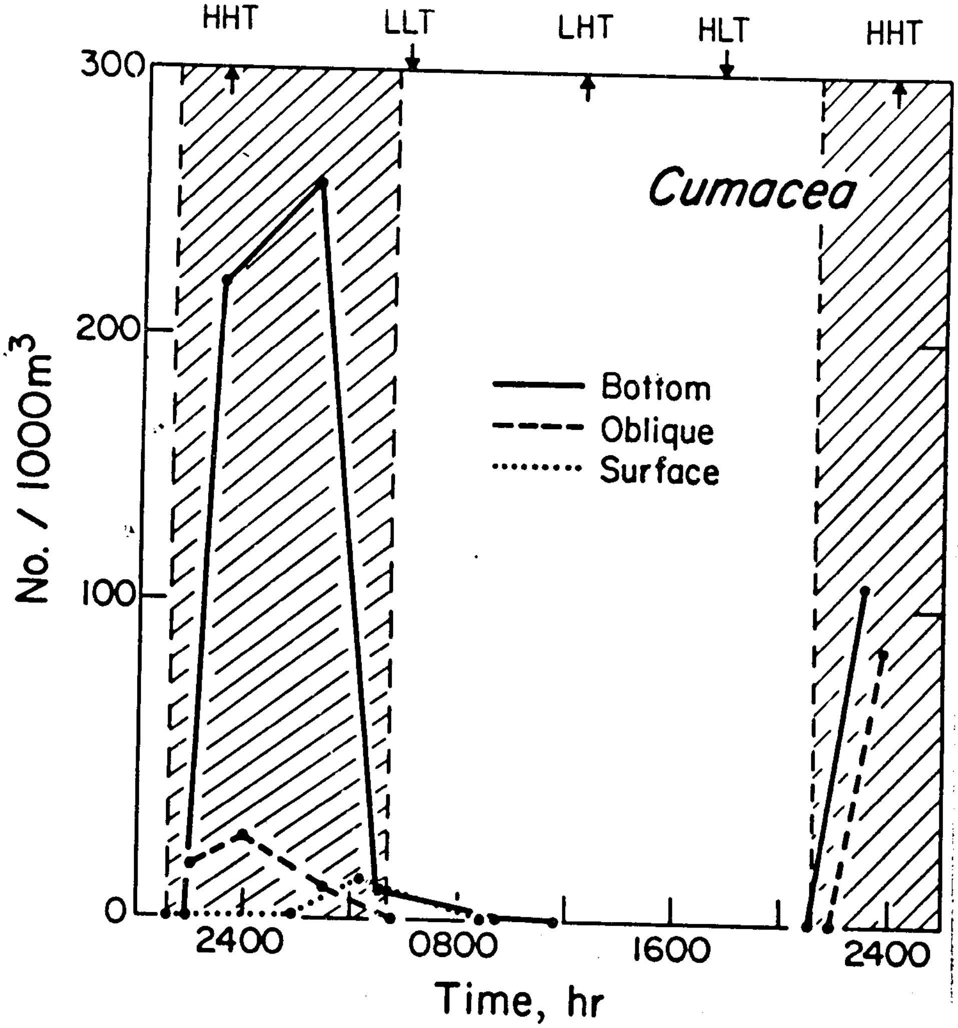

Figure D7. Cumacea from surface, bottom, and oblique 1-m net tows at Station 2 on 20 and 21 June 1975

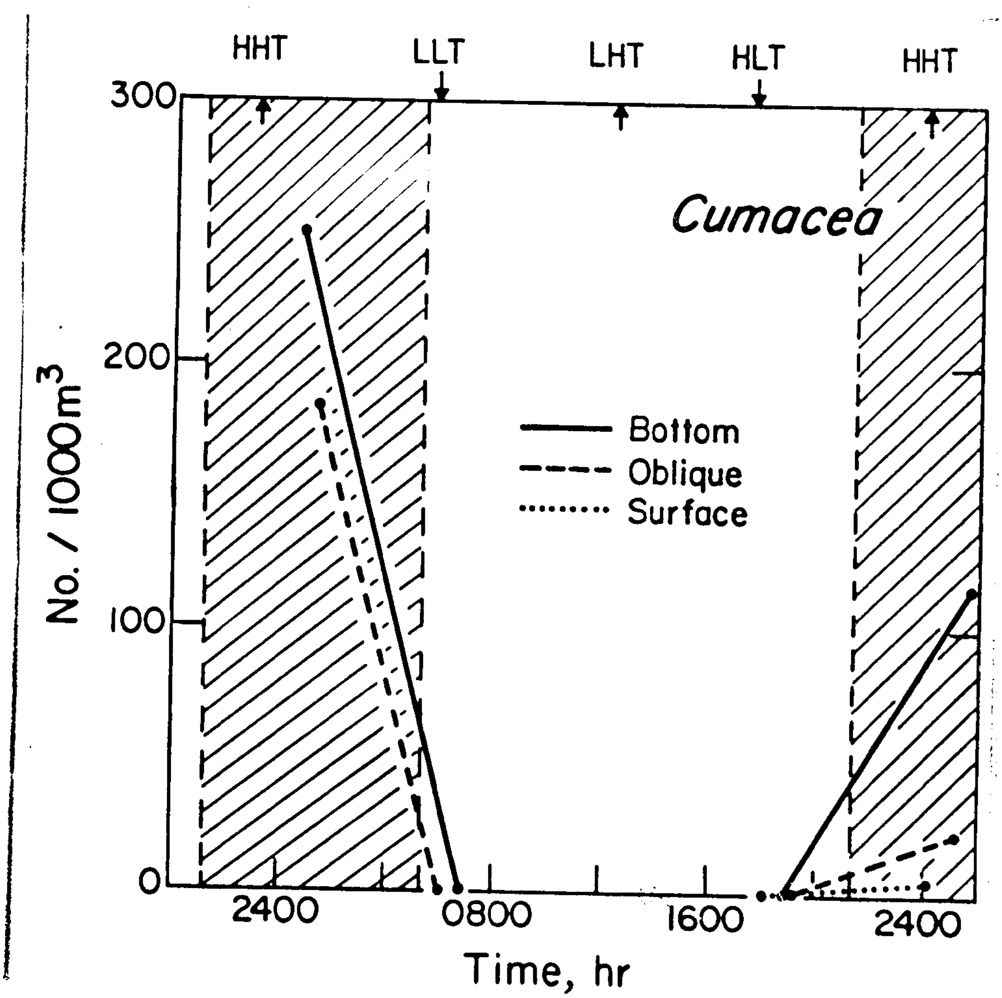

Figure D8. Cumacea from surface, bottom, and oblique 1/2-m net tows at Station 2 on 20 and 21 June 1975

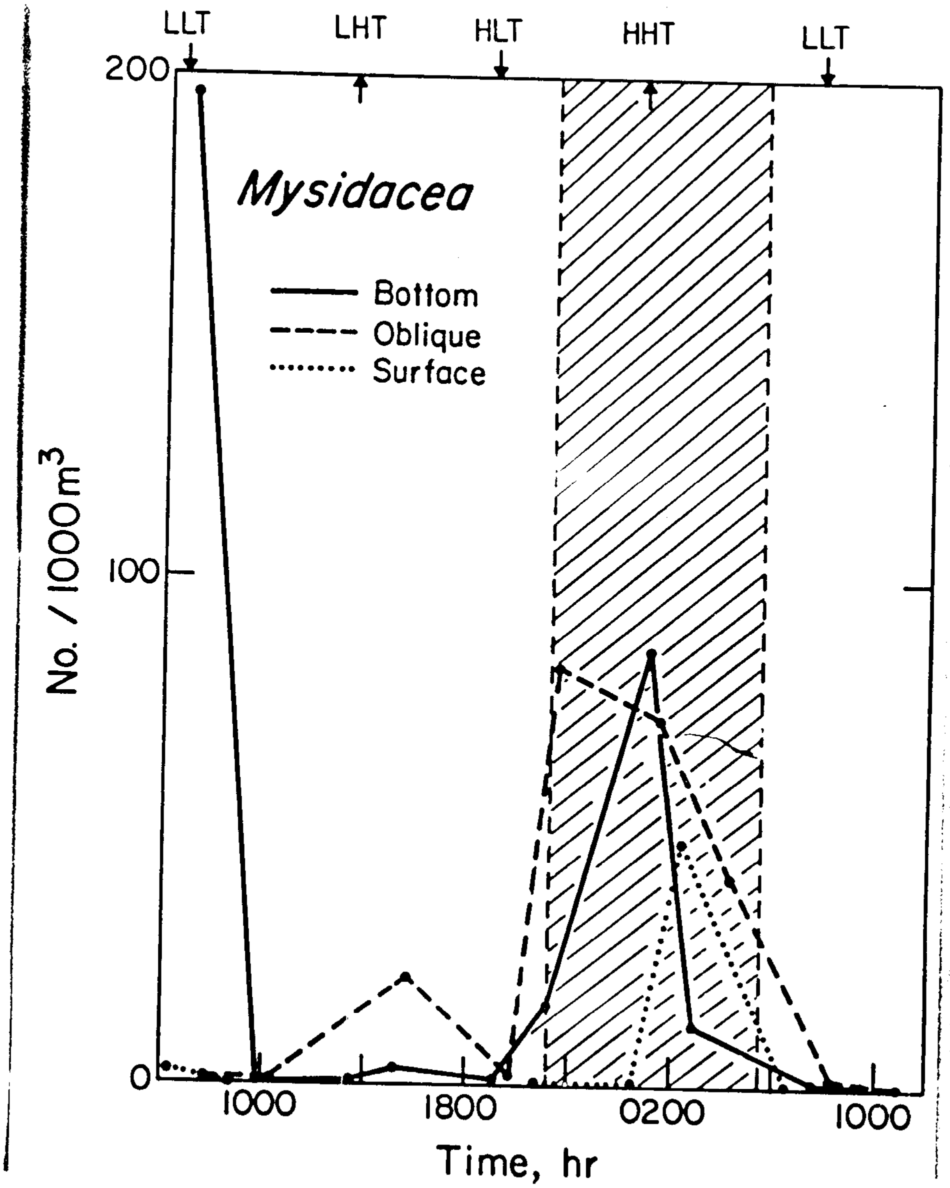

Figure D9. Mysidacea from surface, bottom, and oblique 1-m net tows at Station 4 on 22 and 23 June 1975

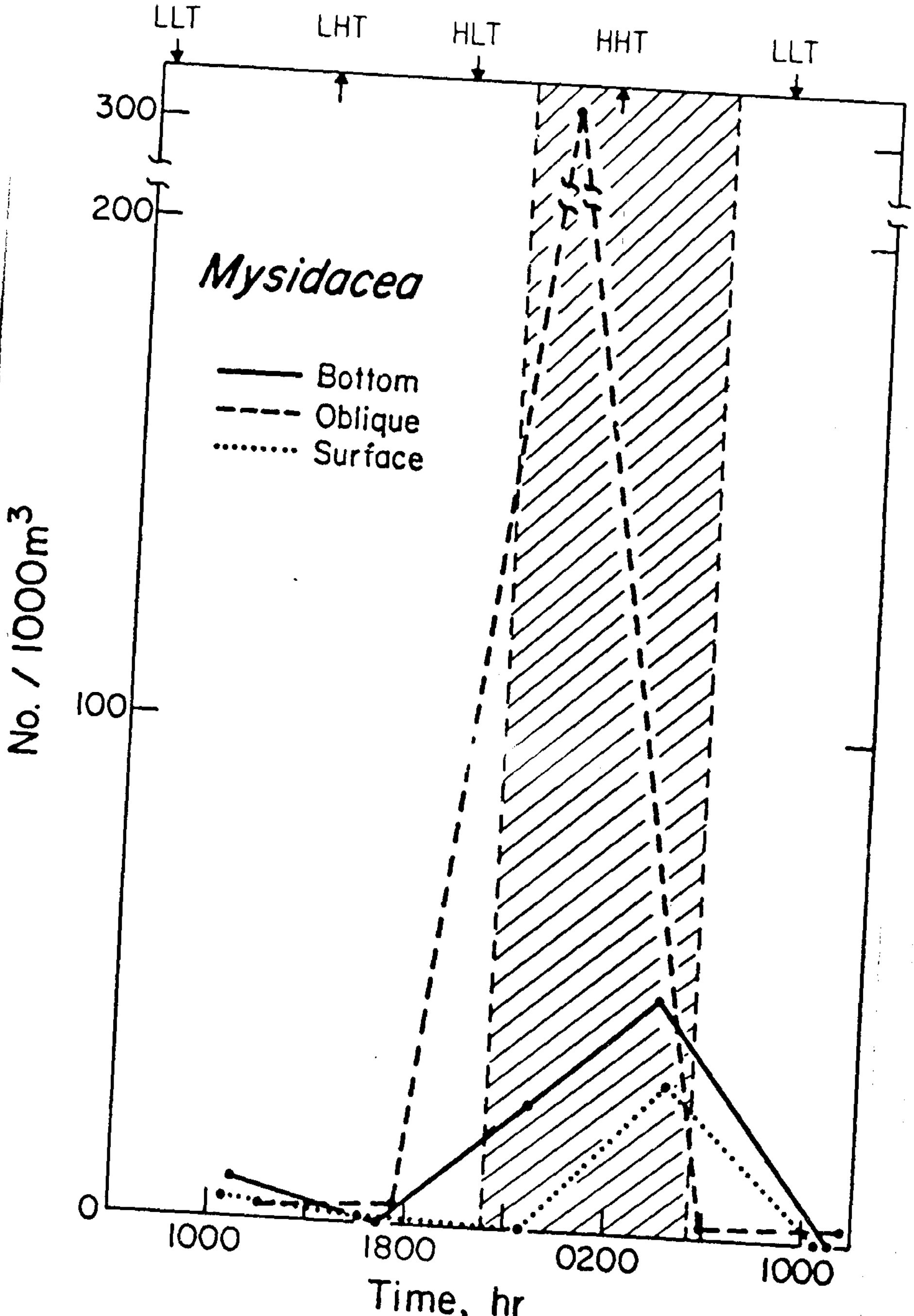

Figure D10. Mysidacea from surface, bottom, and oblique 1/2-m net tows at Station 4 on 22 and 23 June 1975

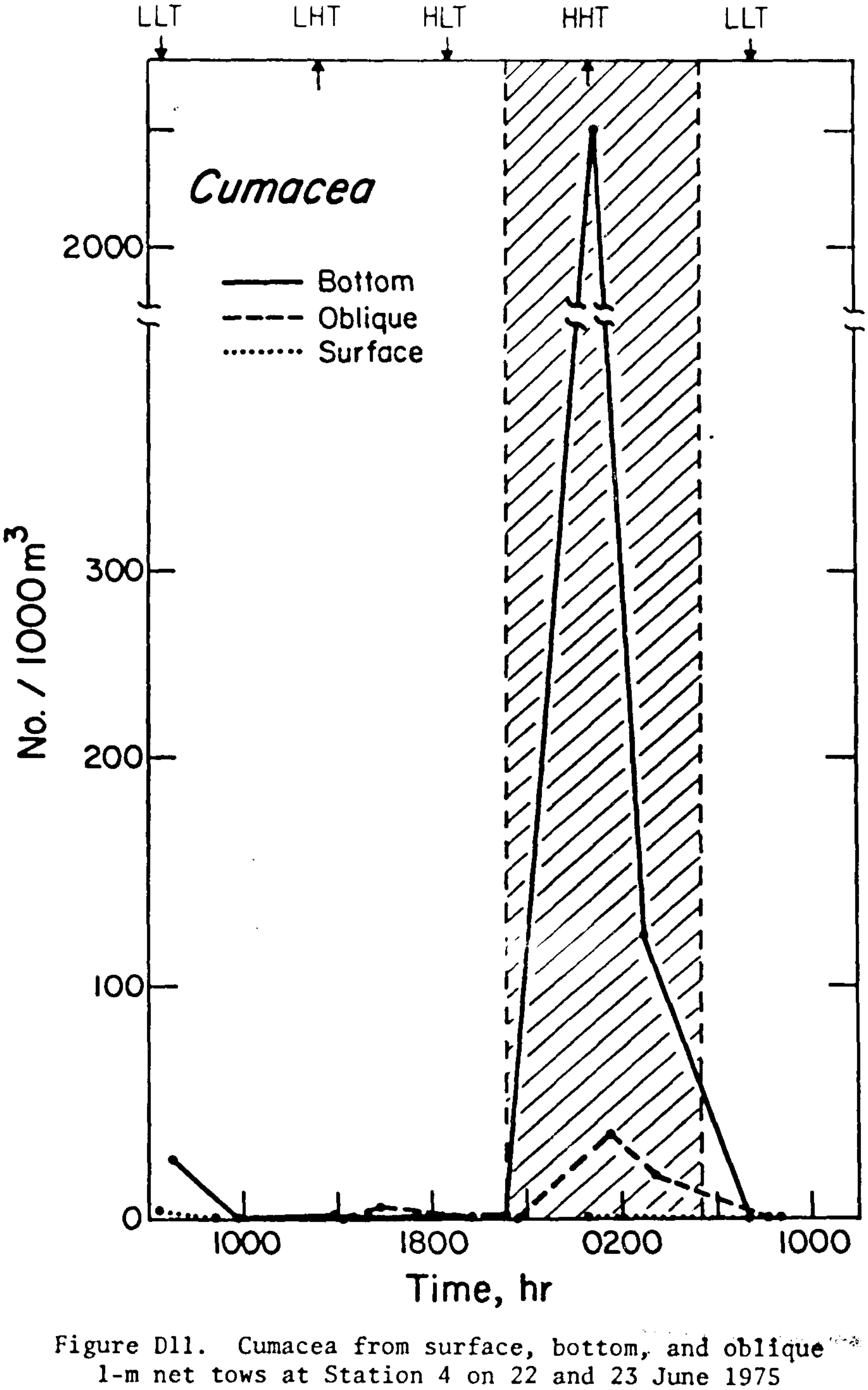

Figure D11. Cumacea from surface, bottom, and oblique 1-m net tows at Station 4 on 22 and 23 June 1975

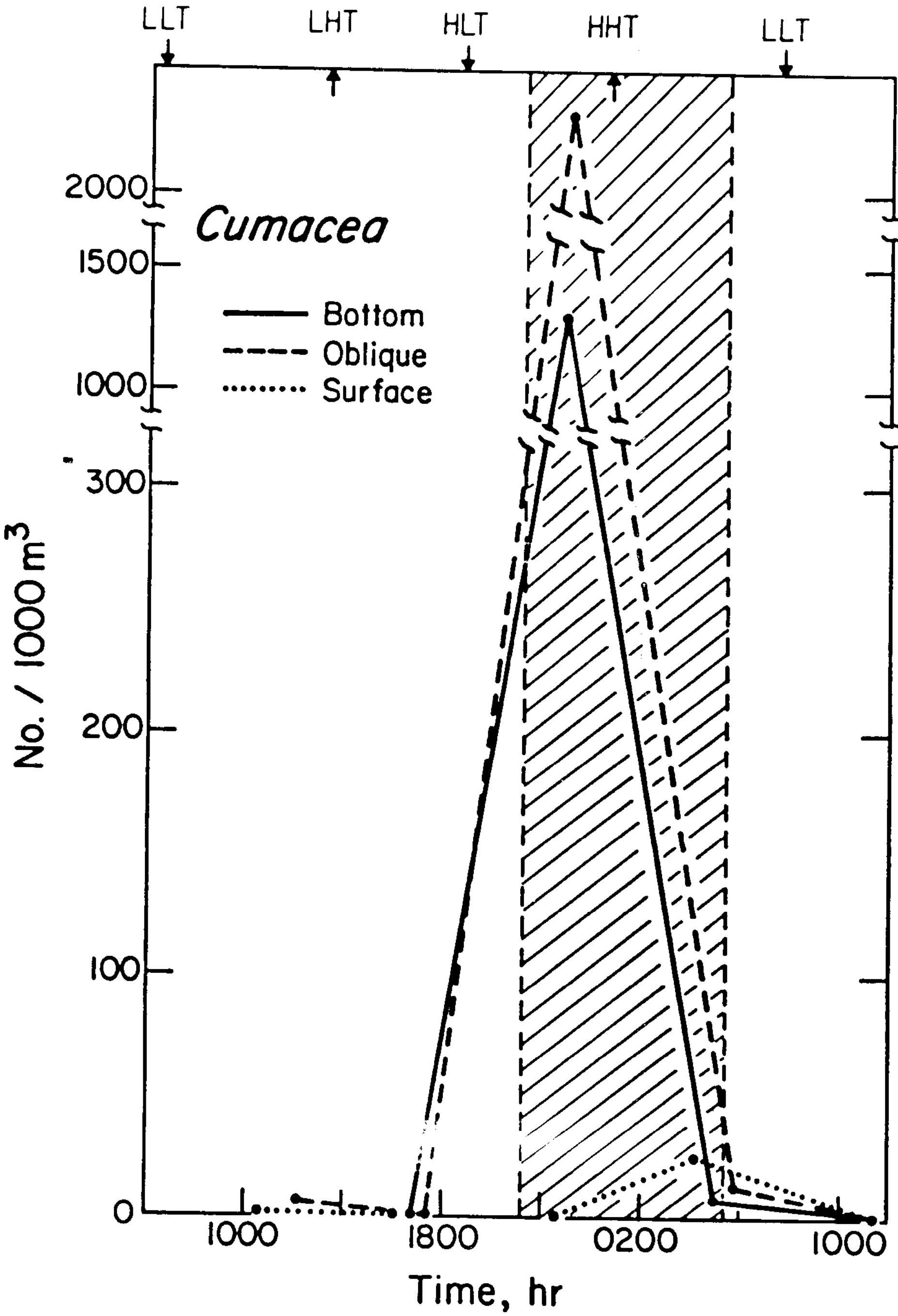

Figure D12. Cumacea from surface, bottom, and oblique 1/2-m net tows at Station 4 on 22 and 23 June 1975

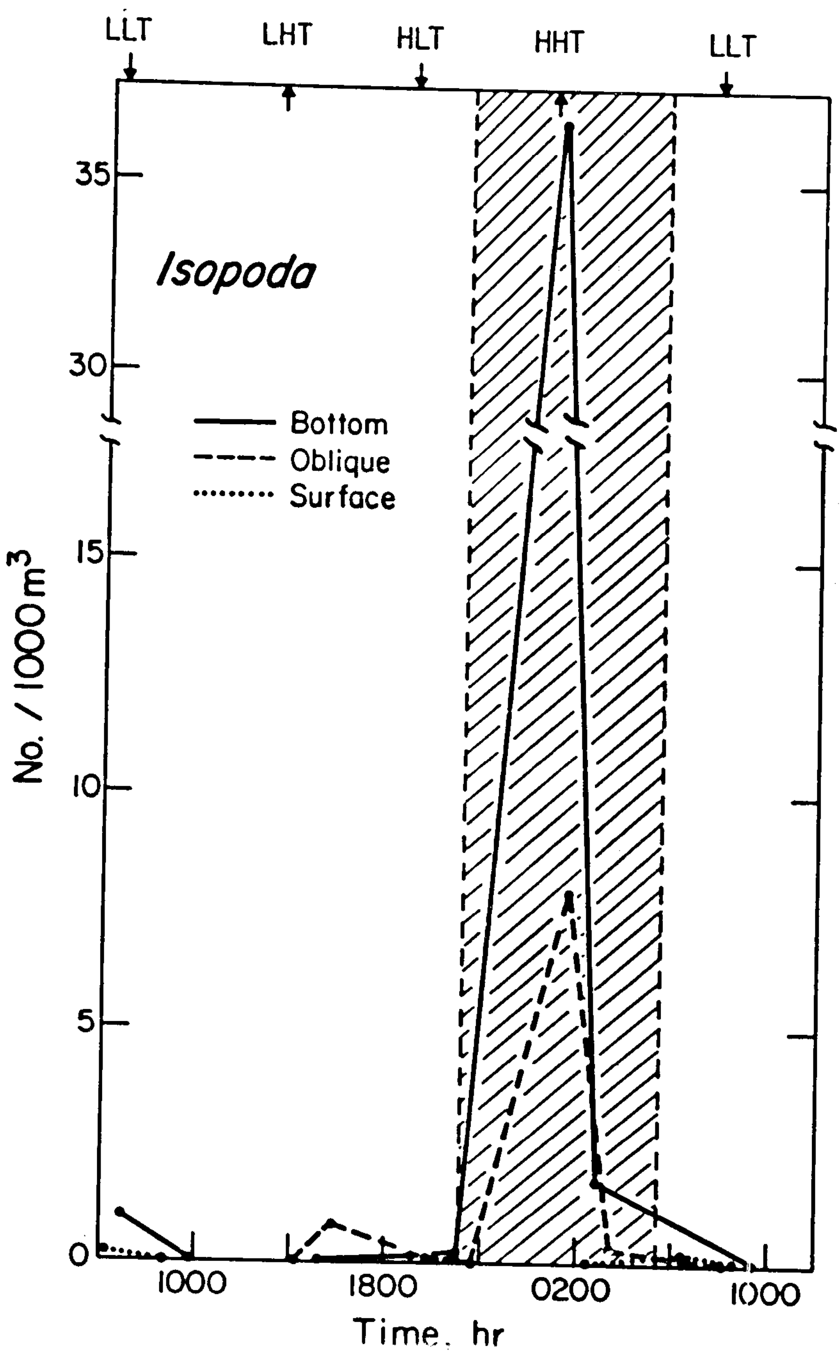

Figure D13. Isopoda from surface, bottom, and oblique 1-m net tows at Station 4 on 22 and 23 June 1975

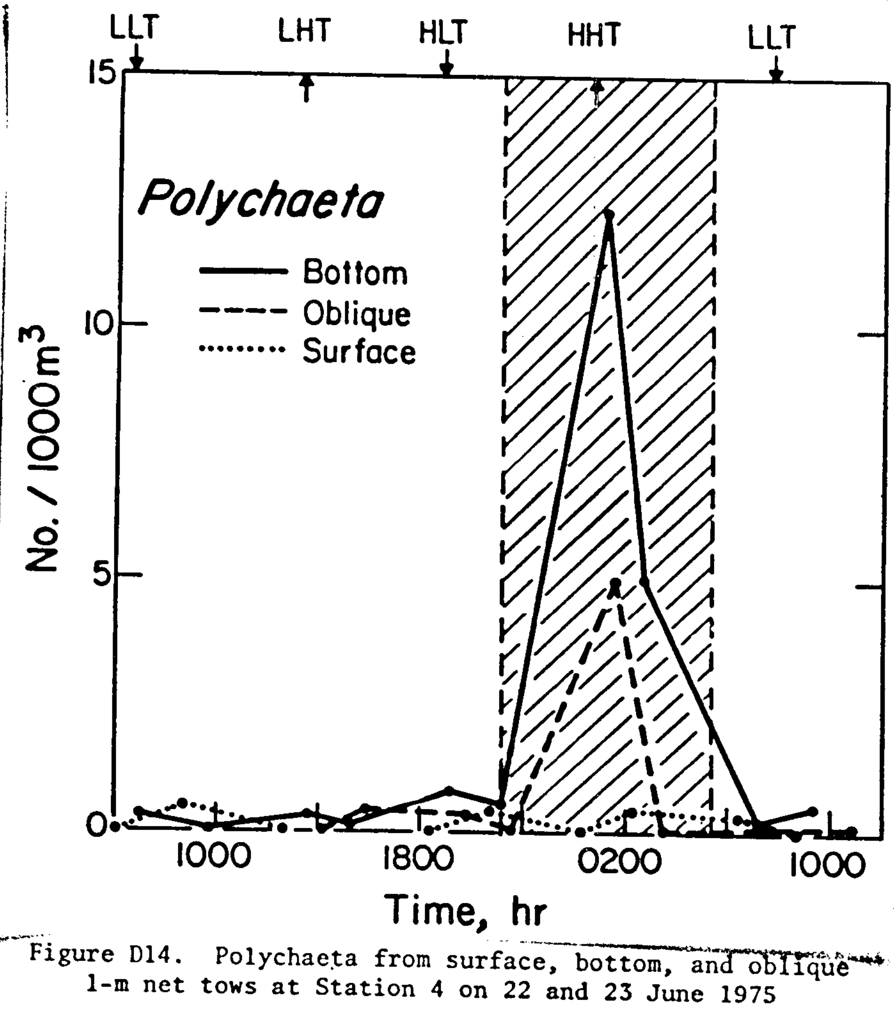

Figure D14. Polychaeta from surface, bottom, and oblique 1-m net tows at Station 4 on 22 and 23 June 1975

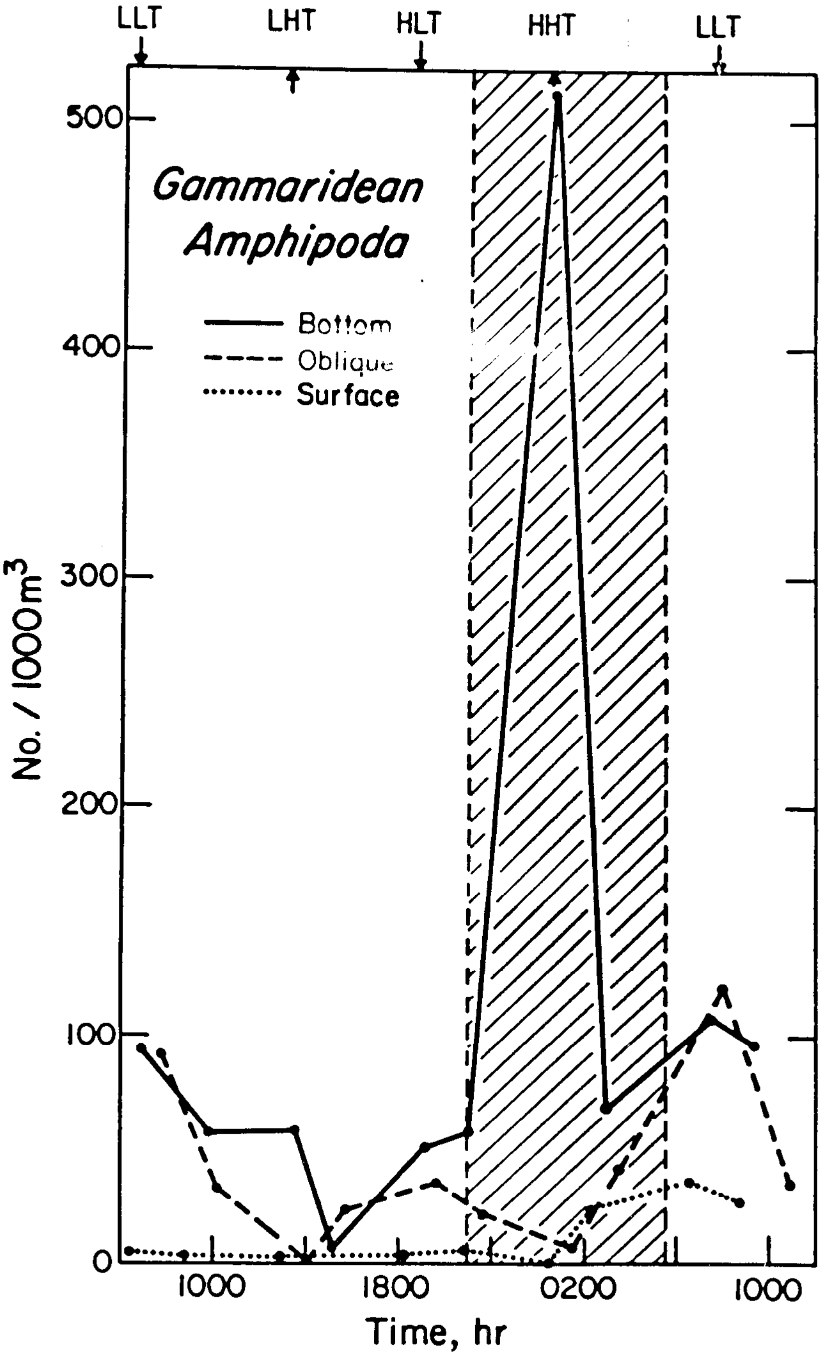

Figure D15. Gammaridean Amphipoda from surface, bottom, and oblique 1-m net tows at Station 4 on 22 and 23 June 1975

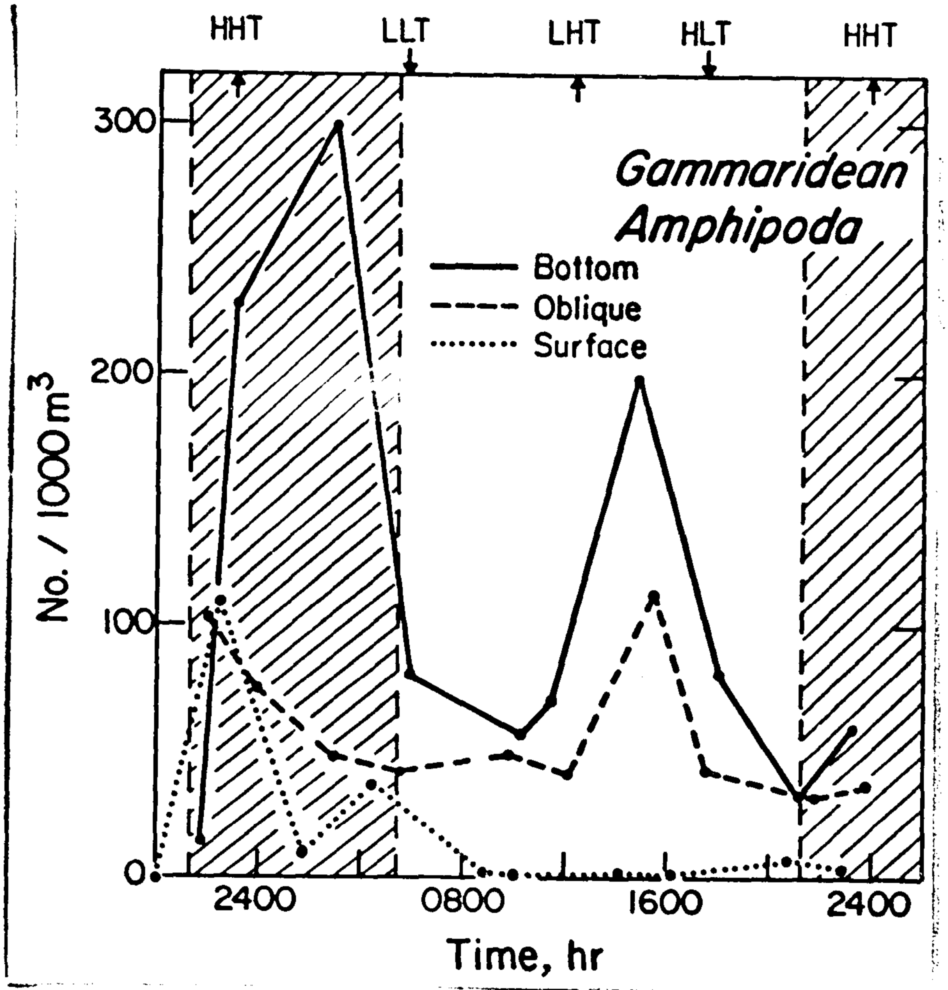

Figure D16. Gammaridean Amphipoda from surface, bottom, and oblique 1-m net tows at Station 2 on 20 and 21 June 1975

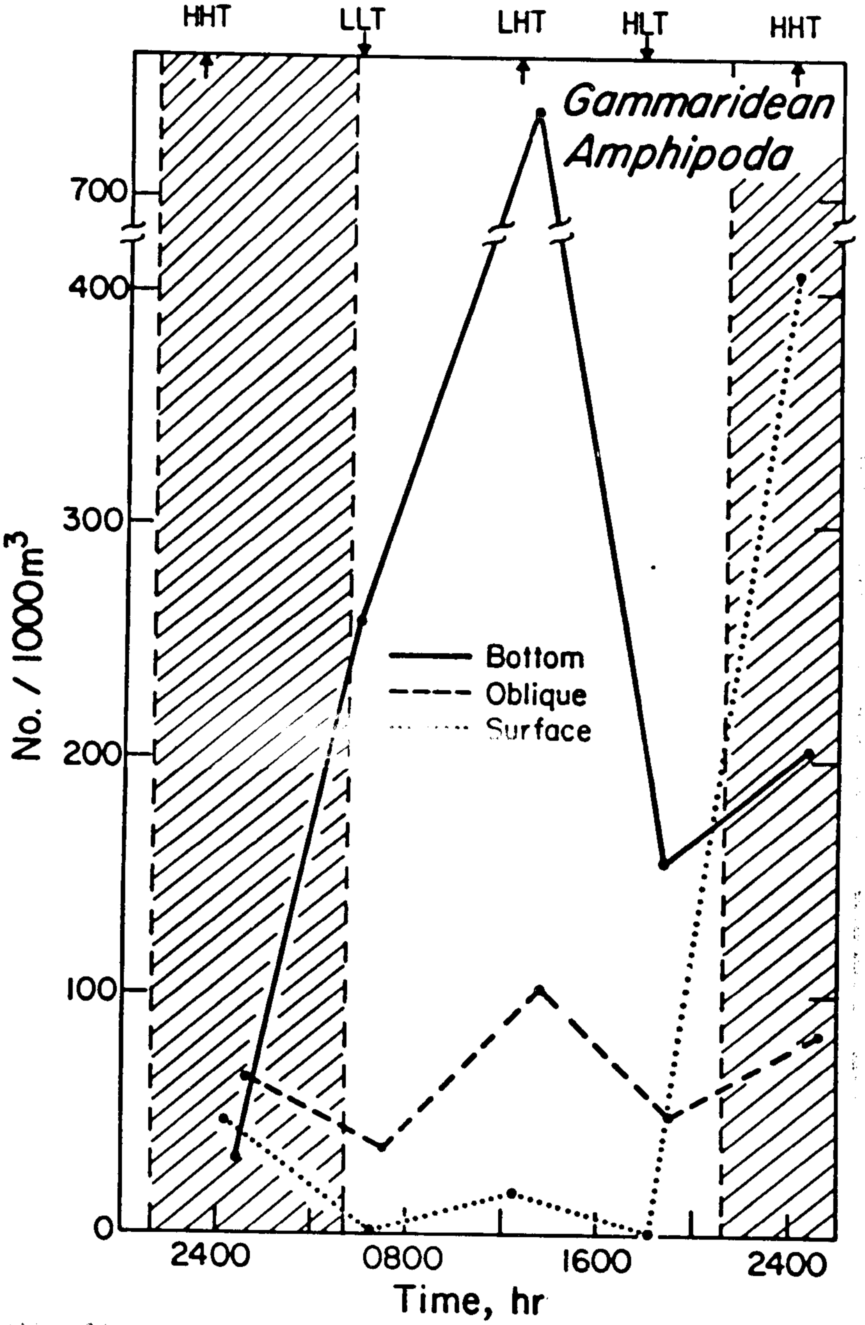

Figure D17. Gammaridean Amphipoda from surface, bottom, and oblique 1/2-m net tows at Station 2 on 20 and 21 June 1975

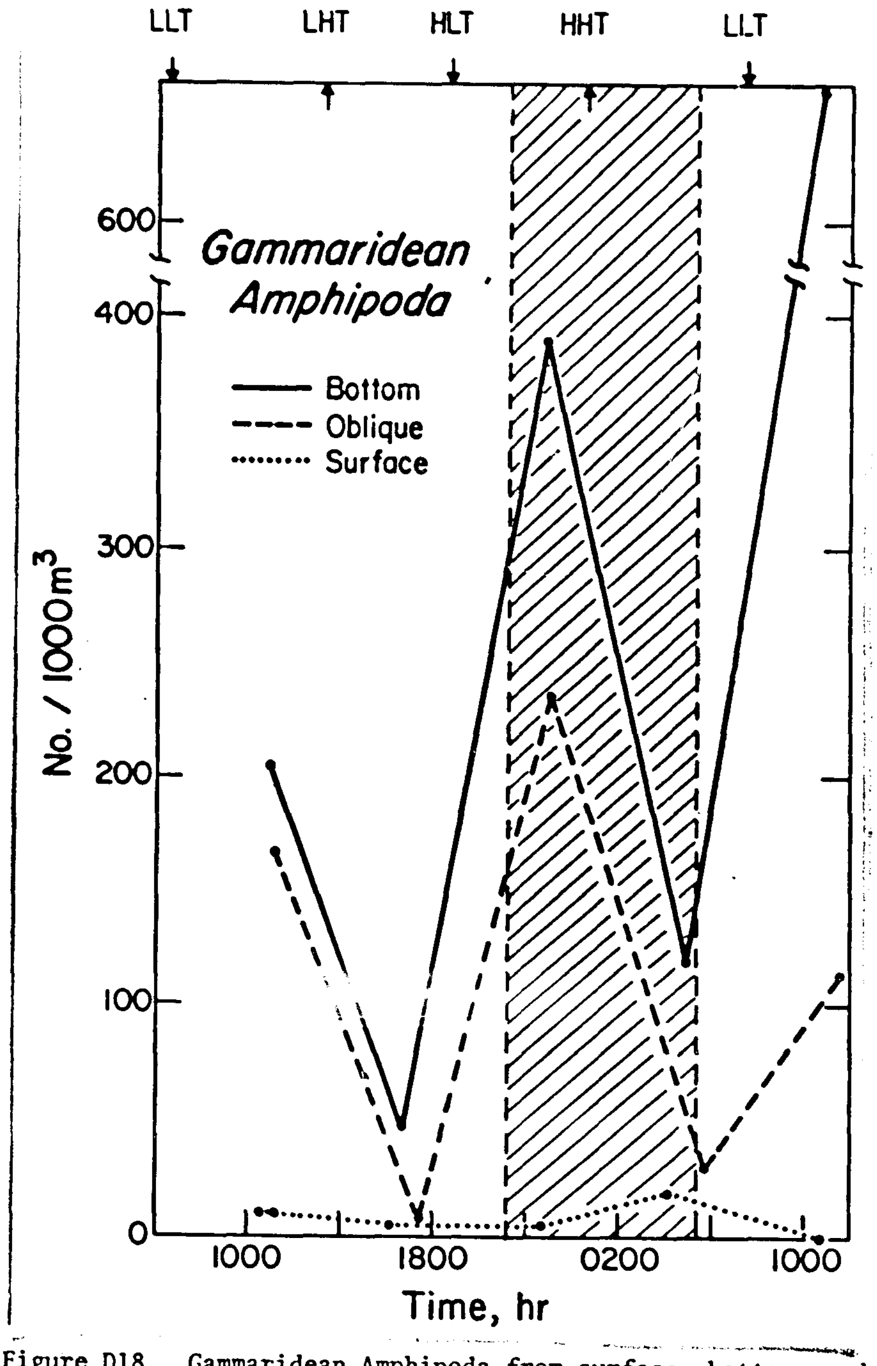

Figure D18. Gammaridean Amphipoda from surface, bottom, and oblique 1/2-m net tows at Station 4 on 22 and 23 June 1975

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i, 46 p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-77-30, Appendix D)

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract Nos. DACW57-75-C-0155 and DACW57-76-C-0091 (DMRP Work Unit No. 1A07D)

This report on microfiche in main report.

References: p. 19.

Bibliography: p. 20-21.

1. Columbia River. 2. Dredged material. 3. Dredged material disposal. 4. Field investigations. 5. Fishes. 6. Plankton. 7. Ichthyoplankton. 8. Waste disposal sites. 9. Zooplankton.

(Continued on next card)

Holton, Robert L

Aquatic disposal field investigations, Columbia River disposal site, Oregon; Appendix D: Zooplankton and ichthyoplankton studies ... 1978. (Card 2)

I. Small, Lawrence F., joint author. II. Oregon. State University, Corvallis. School of Oceanography. III. United States. Army. Corps of Engineers. IV. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-77-30, Appendix D)

TA7.W34 no.D-77-30 Appendix D