SPECIES COMPOSITION AND DISTRIBUTION OF MARINE NEKTON IN THE PACIFIC OCEAN OFF OREGON

by

William G. Pearcy

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September 1961 - May 1962 May 1962
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PACIFIC OCEAN OFF OREGON

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Atomic Energy Commission
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Approved:

Wayne V. Burt, Chairman
Department of Oceanography

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INTRODUCTION

Knowledge of the pelagic organisms in vast areas of the open ocean is very limited. This is particularly true of the small nekton or swimming forms such as fishes, squid, prawns and euphausiids, which are important as intermediate animals in the food chain and are preyed upon by species such as salmon and albacore. Although small nekton and macroplankton are often known to undertake daily vertical migrations, virtually nothing is known about their horizontal movements or their seasonal variations in time and space. There is a need, therefore, for basic research on the ecology and behavior of these common pelagic animals. A biological study in the Pacific Ocean off Oregon is desirable: first, because several species of small nekton found to accumulate the radionuclide Zinc-65 discharged by the Columbia River may be instrumental in the transport of this isotope at sea; secondly, because the area has never been adequately surveyed, so our knowledge of the composition of the pelagic community is meager.

During the summer of 1961, we initiated an investigation of the ocean off Oregon which entails systematic sampling throughout the year with a high-speed midwater trawl. Comparison of seasonal differences in species composition and relative abundance is obviously premature at this time and must await the completion of a year's sampling. This initial progress report, therefore, is confined to a preliminary listing of the animals collected, an assessment of sampling problems, and the variations associated with daily vertical migrations and depth distribution.

METHODS

Collections of nekton and macroplankton are made with a six-foot Isaacs-Kidd midwater trawl (Isaacs and Kidd, 1953; Aron, 1962) sampling along a line of stations extending over 100 miles from the Oregon coast (Fig. 1). Standard oblique tows are taken monthly at night in the upper 200 m at the stations off Newport, and bimonthly at the stations off the mouth of the Columbia River and Coos Bay (weather permitting), in conjunction with the regular hydrographic cruises. The procedure for the standard 200 m oblique is to lower the net until 730 m of cable is out, then to retrieve at a constant speed of about 30 m per minute, all while steaming at 6 knots. Geographic position is recorded at the start and end of tow. Wire-depth relationships are determined either with a bathythermograph or a depth gauge.

In addition to these samples along offshore lines of stations, repeated samples are taken during a 12-48 hour period at a station 50 miles off Newport over the continental slope. These include either (1) replicate tows to 200 m depth and (2) tows to different depths from the surface to over 1000 m.
In the laboratory, all fishes, squid and other large nektonic animals are sorted from the sample and the remaining macroplankton is subsampled with a plankton splitter for further examination.

RESULTS

A total of 171 collections made with the midwater trawl to date indicate the success of the sampling program. Stations were regularly sampled even during the winter, a period for which little data existed on the nektonic animals off the Oregon coast.

A partial list of the animals identified from the midwater samples is given in Table I-A (Fishes) and Table I-B (Squid, crustacea, and other invertebrates). Several animals of great interest were collected, including a whale fish or Cetomimidae, which may represent a new genus, and a new species of gonatid squid (Pearcy and Voss, ms).

The fishes (Table I-A) are dominated by bathypelagic species with incidental members of either (a) epipelagic species of the open ocean or coastal waters or (b) juveniles of benthic forms. Since sorting, identification, and tabulation of the data are completed only for the midwater fishes at present, the analyses herein will be confined to these animals, particularly those captured 50 miles off Newport (NH-50), where a detailed study is being made to determine variability and depth distribution.

Variation of Tow Lengths and Fish Catch

A total of 28 replicate tows were taken at NH-50 to a depth of about 200 m. Figure 1 shows a circle at NH-50 encompassing the locations of these collections. The average time to retrieve 730 m of cable from 200 m depth was 29 minutes (variance, s² = 8.4), and the average total time of the hauls was 44 minutes, with a higher variance (s² = 33). Since there was appreciable variation in the time for descent of the net, due mainly to unavoidable delays at the surface (weather conditions or operational difficulties) the total time and catch of bathypelagic fishes for these tows was plotted to examine the relationship between the duration of the tow and the number of fish captured. Figure 2 shows a considerable variation in the catch for both short and long tows. The slope of the regression, by the method of least squares, between total fish catch (Y) and the time (X), is non-significant (F = 4.06); moreover, no relationship between these variables is apparent for the most extensive series of tows during a single night (solid circles). These data suggest that few fish are captured while the net is delayed at the surface streaming in the wake of the vessel or while it is descending.
FIGURE 1. Location of midwater trawl stations off Oregon. Numbers designate the distance in miles from the coast. The large circle at NH-50 circumscribes the replicate series.
FIGURE 2. The total number of bathypelagic fishes collected in replicate tows of various duration at NH-50.
TABLE I. Preliminary list of animals collected by midwater trawling.

A. Fishes, including their presence in tows to 200, 500, and 1000 meters depth at NH-50. (identifications by W. Pearcy and M. Laurs)

<table>
<thead>
<tr>
<th>Species</th>
<th>Depth in Meters (NH-50)</th>
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</thead>
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<tr>
<td></td>
<td>0-200</td>
</tr>
<tr>
<td>Agonidae</td>
<td></td>
</tr>
<tr>
<td>Argyropelecus olfersii</td>
<td>+</td>
</tr>
<tr>
<td>Aristostomias scintillans</td>
<td></td>
</tr>
<tr>
<td>Bathophilus flemingi</td>
<td>+</td>
</tr>
<tr>
<td>Bathylagus milleri</td>
<td></td>
</tr>
<tr>
<td>B. ochotensis</td>
<td>+</td>
</tr>
<tr>
<td>B. pacificus</td>
<td>+</td>
</tr>
<tr>
<td>Chauliodus macouni</td>
<td>+</td>
</tr>
<tr>
<td>Cololabis sairi</td>
<td>+</td>
</tr>
<tr>
<td>Cyclothone acclinidens</td>
<td>+</td>
</tr>
<tr>
<td>C. microdon</td>
<td>+</td>
</tr>
<tr>
<td>C. pallida</td>
<td></td>
</tr>
<tr>
<td>C. signata</td>
<td>+</td>
</tr>
<tr>
<td>C. sp. &quot;A&quot;</td>
<td></td>
</tr>
<tr>
<td>C. sp. &quot;B&quot;</td>
<td></td>
</tr>
<tr>
<td>Danaphos oculatus</td>
<td></td>
</tr>
<tr>
<td>Diaphus theta</td>
<td>+</td>
</tr>
<tr>
<td>Entosphenus tridentatus</td>
<td></td>
</tr>
<tr>
<td>Hierops crokeri</td>
<td></td>
</tr>
<tr>
<td>H. thompsoni</td>
<td></td>
</tr>
<tr>
<td>Holtbyrnia polycoeca</td>
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</tr>
<tr>
<td>Idiacanthus antrostomus</td>
<td></td>
</tr>
<tr>
<td>I. sp.</td>
<td></td>
</tr>
<tr>
<td>Lampanyctus leucopsarus</td>
<td>+</td>
</tr>
<tr>
<td>L. nannochir</td>
<td></td>
</tr>
<tr>
<td>L. regalis</td>
<td>+</td>
</tr>
<tr>
<td>L. ritteri</td>
<td>+</td>
</tr>
<tr>
<td>L. n. sp.</td>
<td></td>
</tr>
<tr>
<td>Lestidium ringens</td>
<td></td>
</tr>
<tr>
<td>Liparidae</td>
<td></td>
</tr>
<tr>
<td>Lycocephalus mandibularis</td>
<td></td>
</tr>
<tr>
<td>Macropinna microstoma</td>
<td></td>
</tr>
<tr>
<td>Melamphaes rugosus</td>
<td></td>
</tr>
<tr>
<td>Microgadus proximus</td>
<td></td>
</tr>
<tr>
<td>Myctophum californiense</td>
<td></td>
</tr>
<tr>
<td>Nectoliparis pelagicus</td>
<td></td>
</tr>
<tr>
<td>Nemichthys avocetta</td>
<td></td>
</tr>
<tr>
<td>Neoscopelarchoides dentatus</td>
<td></td>
</tr>
<tr>
<td>Scorpaenichthys marmoratus</td>
<td></td>
</tr>
<tr>
<td>Searsidae</td>
<td></td>
</tr>
<tr>
<td>Sebastodes</td>
<td>+</td>
</tr>
<tr>
<td>Tactostoma cacropus</td>
<td>+</td>
</tr>
<tr>
<td>Tarletonbeania crenularis</td>
<td>+</td>
</tr>
<tr>
<td>Thaleichthys pacificus</td>
<td></td>
</tr>
</tbody>
</table>
TABLE I-A. Fishes (Continued)

**LARVAL FISH**

Cottidae  
Eel leptocephalus  
Engraulis sp.  
Glyptocephalus zachirus  
Microstomus pacificus  
Myctophidae  
Pleuronectiformes  
Scorpaenidae  
Sebastodes spp.  
Stomiatoidea  
Thaleichthys sp.  
Unidentified

**B. Invertebrates**

**CEPHALOPODA  (identifications by W. Pearcy)**

Japatella heathi  
Rossia pacifica  
Onychoteuthis banksii  
Gonatidae  
Gonatus fabricii  
Gonatus n. sp.  
Gonatopsis borealis  
Chiroteuthis veranyi  
Octopodoteuthinae  
Abraliopsis sp.  
Taonis sp.  
Galiteuthis sp.  
Toxeuma sp.

**EUPHAUSIACEA  (identifications by F. Hebard)**

Euphausia pacifica  
Nematobrachion flexipes  
Nematoscelis sp.  
Stylocheilon sp.  
Tessarabrachion oculatus  
Thysanoessa longipes  
Thysanoessa spinifera
<table>
<thead>
<tr>
<th>COPEPODA (identifications by F. Hebard)</th>
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<tbody>
<tr>
<td>Acartia danae</td>
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<tr>
<td>Aetideus armatus</td>
</tr>
<tr>
<td>Calanus cristatus</td>
</tr>
<tr>
<td>Calanus finmarchicus</td>
</tr>
<tr>
<td>Calanus plumchrus</td>
</tr>
<tr>
<td>Candacia pachydaactyla</td>
</tr>
<tr>
<td>Eucalanus bungii</td>
</tr>
<tr>
<td>Euchaeta japonica</td>
</tr>
<tr>
<td>Gaetanus simples</td>
</tr>
<tr>
<td>Heterorhabdus papilliger</td>
</tr>
<tr>
<td>Metridia lucens</td>
</tr>
<tr>
<td>Metridia pacifica</td>
</tr>
<tr>
<td>Metridia sp.</td>
</tr>
<tr>
<td>Oithona spinirostris</td>
</tr>
<tr>
<td>Oithona similis</td>
</tr>
<tr>
<td>Oncaea borealis</td>
</tr>
<tr>
<td>Pleuromamma quadrungulata</td>
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<tr>
<td>Pleuromamma xiphias</td>
</tr>
<tr>
<td>Pseudocalanus minutus</td>
</tr>
<tr>
<td>Scaphocalanus magnus</td>
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<tr>
<td>Scottocalanus persecans</td>
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</tbody>
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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Oikopleura sp.</td>
</tr>
<tr>
<td>Salpa fusiformis</td>
</tr>
<tr>
<td>Salpa aspera</td>
</tr>
<tr>
<td>Iasis (Salpa) zonaria</td>
</tr>
<tr>
<td>Salpa sp.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MYSIDACEA (identifications by W. Renshaw)</th>
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<tbody>
<tr>
<td>Gnathophausia ingens</td>
</tr>
<tr>
<td>Eucopia australis</td>
</tr>
<tr>
<td>Boreomysis rostrata</td>
</tr>
<tr>
<td>Boreomysis sp.</td>
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<table>
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<th>PTEROPODA (identifications by W. Renshaw)</th>
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<tr>
<td>Limacina helicoides</td>
</tr>
<tr>
<td>Clione limacina</td>
</tr>
</tbody>
</table>
### TABLE I-B. Invertebrates (Continued)

#### CHAETOGNATA (identifications by W. Renshaw)

- *Sagitta bierii*
- *S. decipiens*
- *S. euneritica*
- *S. elegans*
- *S. macrocephala*
- *S. minima*
- *S. scrippseae*
- *S. zetesios*
- *Eukrohnia bathypelagica*
- *E. fowleri*
- *E. hamata*

#### MEDUSAE (identifications by W. Renshaw)

- *Sarsia princeps*
- *S. tubulosa*
- *Aglantha digitale*
- *Colobonema sericeum*
- *Crossota norvegica*
- *C. rufobrunnea*
- *Pantachogon haeceli*
- *Halistaura cellularia*
- *Aequorea sp. (fragments)*
- *Aegina citrea*
- *Solmissus marshalli*
- *Atolla vanhoefini*
- *A. wyvillei*
- *Periphylla periphylla*

#### SIPHONOPHORA (identifications by W. Renshaw)

- *Vogtia spinosa*
- *Nectodroma dubia*
- *N. reticulata*
- *Nectopyramis diomedae*
- *Lensia conoidea*
- *Abyla sp.*
- *Nanomia bijuga*
- *Stephanomia sp.*
- *Velella velella*

Identifications by the following ichthyologists are acknowledged:

- Stomatoidea - Robert H. Gibbs
- Bathylagidae - Daniel M. Cohen
- Myctophidae - Robert L. Wisner
- Gonostomiatiidae - B. N. Kobayaski
Therefore, based on the data available, a direct comparison of total catch of each standard tow appears justified to show major differences in catches.

Daily Variations in Catches

A basic problem of comparing the relative abundance of animals is the determination of the variability of successive samples. Such a measure of short term variation is essential as a basis for evaluating differences between samples separated in time or space.

To enable a more detailed comparison of variations within a short period, the catches of the four most abundant fishes are shown for various periods of night and day in Table II. These fishes are a stomatoid, Tactostoma macropus, and three myctophids or lantern fishes, Lampanyctus leucopsarus, Tarletonbeania crenularis, and Diaphus theta. The differences between day and night catches in the table are obvious, and the virtual evacuation of the upper 200 m during the day by these bathypelagic species is interpreted as a reflection of their daily vertical migrations to deep water during the day and into surface waters at night.

Although differences between day and night catches are obvious, with intermediate numbers occurring during twilight periods, there is no evident trend in the availability of fishes during the night which indicates any major variations associated with time. High or low catches may appear irregularly for these four species throughout the night. Catches close to sunset or sunrise are not consistently lower than those made around midnight, suggesting that fish ascend quickly to the upper 200 m one to two hours after sunset and generally stay within this zone until shortly before dawn. Neither is there evidence for a midnight sinking or dawn rise (cf. Cushing, 1951) from this depth interval. Hence, though fishes may be migrating through the 0-200 m column of water during the night, we may assume that all tows during this period are sampling the same migrating population. (Table II also shows that during the winter the fishes are present in the surface waters at an earlier local time and remain for a longer period; this is expected if submarine light intensity is the major stimulus for their migratory behavior.)

Assuming that tows during the night represent replicate samples, a basis is provided for the estimation of sampling variability—a useful statistic for evaluating the significance of subsequent comparisons of spatial and temporal variations. Coefficients of dispersion, \( \frac{X}{s^2} \) (Blackman, 1942), were calculated from the data given in Table II; they ranged from 0.3 to 12.3. If the variance of a random (Poisson) distribution is equal to the mean, the departure from randomness will be reflected by variance. Coefficients of dispersion greater than 1 suggest aggregation, and those less than 1 suggest uniform distribution. The significance of the deviation from unity is determined by the formula...
TABLE II. Catches of four common species of bathypelagic fish in upper 200 m at NH-50.

<table>
<thead>
<tr>
<th>HOUR</th>
<th>1600</th>
<th>2000</th>
<th>0000</th>
<th>0400</th>
<th>0800</th>
<th>1200</th>
<th>1600</th>
<th>2000</th>
<th>0000</th>
<th>0400</th>
<th>0800</th>
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**DAY**

<table>
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<th>13 July 1961</th>
<th>14 July 1961</th>
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<tbody>
<tr>
<td>T. macropus</td>
<td>3* 4 6**</td>
<td>8*</td>
<td>10 11 12 14</td>
</tr>
<tr>
<td>L. leucopsar</td>
<td>0 0 0</td>
<td>26</td>
<td>5 14 5 1</td>
</tr>
<tr>
<td>T. crenularis</td>
<td>0 0 3</td>
<td>0 1 0 1</td>
<td></td>
</tr>
<tr>
<td>D. theta</td>
<td>0 0 5</td>
<td>0 1 0 10</td>
<td></td>
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</table>

**NIGHT**

<table>
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<th>18 July 1961</th>
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</thead>
<tbody>
<tr>
<td>T. macropus</td>
<td>3 2 1</td>
<td>3 1 1 0</td>
<td>0</td>
</tr>
<tr>
<td>L. leucopsar</td>
<td>8 5 6</td>
<td>15 25 9 1</td>
<td>0</td>
</tr>
<tr>
<td>T. crenularis</td>
<td>4 30 1</td>
<td>7 11 3 0</td>
<td>0</td>
</tr>
<tr>
<td>D. theta</td>
<td>13 9 3</td>
<td>8 11 2 0</td>
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**DAY**

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<td>T. macropus</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L. leucopsar</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>T. crenularis</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>D. theta</td>
<td>13</td>
<td>1</td>
</tr>
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**NIGHT**

<table>
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<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T. macropus</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>L. leucopsar</td>
<td>2</td>
<td>4</td>
<td>3 5</td>
<td>0</td>
</tr>
<tr>
<td>T. crenularis</td>
<td>0</td>
<td>1</td>
<td>1 0</td>
<td>0</td>
</tr>
<tr>
<td>D. theta</td>
<td>3</td>
<td>2</td>
<td>5 3</td>
<td>0</td>
</tr>
</tbody>
</table>

* Depth - 130 m.
**Depth - 241 m.
\[ 1 + \sqrt{\frac{2n}{(n-1)^2}} \]

where \( n \) is the number of samples. Of the 16 coefficients calculated for the four common fishes, 6 were significantly less than expected for a random distribution, indicating uniformity, and three were higher, indicating aggregation. If the average catch of a species is plotted against its variance for each series, (Fig. 3), it can be seen that when the catches are low the points are distributed close to the line where \( s^2 = \bar{x} \), whereas at high catches there is a marked departure from this relationship, depicting clumping at high densities. A similar relationship has been found for marine plankton (e.g., Barnes and Marshall, 1951). Since aggregation was demonstrated only in samples taken in July, there may be seasonal differences in distribution related to schooling or breeding activity. More samples are necessary to examine this possibility, as little is known about the social behavior of these fishes, such as schooling, etc.

DEPTH DISTRIBUTION

Although a detailed analysis of depth distribution is possible only with opening-closing nets, some general observations can be made from available data from successive tows to different depths. The occurrence of the fishes in tows to 200 m, 500 m, and 1000 m at NH-50 is summarized on the right side of Table I-A. Certain species were absent from surface collections and were present only in collections made to 500 m or below, regardless of the time of day. Such deep-water forms include:

- Bathylagus milleri
- B. pacificus
- Cyclothone acclinidens
- C. pallida
- Danaphos oculatus
- Holtbyrnia polycoeca
- Lampanyctus nannochir
- Melamphaes rugosus
- Neoscopelarchoides dentatus

These data give no information on the maximum depth of any species or differences in relative abundance with depth if numbers are low, since contamination of collections occurs when the net is descending or ascending, and it is not possible to determine the exact depth of capture. Nevertheless, the catches of three lantern fishes in the surface waters at night were high enough to permit some comments on their vertical distribution.

Figure 4 shows the differences in the catches of these Myctophidae collected in 12 oblique tows of approximately the same duration made to
FIGURE 3. Catch variability of four bathypelagic fishes as indicated by replicate tows.
FIGURE 4. Vertical variations in the catches of three lantern fish during the night at NH-50 shown as a percent of the total catch of each species (number in parentheses).
various depths during the night at NH-50. (The number of fish is given as a percent of the species total.) These species clearly demonstrate differences in relative abundance at different depths. Well over one-half of Tarletonbeania crenularis were collected right at the surface, whereas relatively few were taken in tows below 10 meters. (This is the only species which has been netted under night-lights.) Neither Diaphus theta and Lampanyctus leucopsarus were collected at the surface but were found in highest numbers at intermediate depths, 10-25 m and 25-30 m respectively.

REFERENCES


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