

NOAA Technical Report NMFS 7



# The Feeding Ecology of Some Zooplankters That are Important Prey Items of Larval Fish

Jefferson T. Turner

July 1984

U.S. DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
National Marine Fisheries Service

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Malcolm Baldrige, Secretary

**National Oceanic and Atmospheric Administration**

John V. Byrne, Administrator

**National Marine Fisheries Service**

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# The Feeding Ecology of Some Zooplankters That are Important Prey Items of Larval Fish<sup>1</sup>

JEFFERSON T. TURNER<sup>2</sup>

## ABSTRACT

Diets of 76 species of fish larvae from most oceans of the world were inventoried on the basis of information in 40 published studies. Although certain geographic, size- and taxon-specific patterns were apparent, certain zooplankton taxa appeared in the diets of larvae of a variety of fish species in numerous localities. Included were six genera of calanoid copepods (*Acartia*, *Calanus*, *Centropages*, *Paracalanus*, *Pseudocalanus*, *Temora*), three genera of cyclopoid copepods (*Corycaeus*, *Oithona*, *Oncaea*), harpacticoid copepods, copepod nauplii, tintinnids, cladocerans of the genera *Evdane* and *Podon*, barnacle nauplii, gastropod larvae, pteropods of the genus *Limacina*, and appendicularians. Literature on feeding habits of these zooplankters reveals that most of the copepods are omnivorous, feeding upon both phytoplankton and other zooplankton. Some taxa, such as *Calanus*, *Paracalanus*, *Pseudocalanus*, and copepod nauplii appear to be primarily herbivorous, while others, such as *Acartia*, *Centropages*, *Temora*, and cyclopoids exhibit broad omnivory or carnivory. The noncopepod zooplankters are primarily filter-feeders upon phytoplankton and/or bacterioplankton. Despite the importance of zooplankters in larval fish food webs, specific knowledge of the feeding ecology of many taxa is poor. Further, much present knowledge comes only from laboratory investigations that may not accurately portray feeding habits of zooplankters in nature. Lack of knowledge of the feeding ecology of many abundant zooplankters, which are also important in larval fish food webs, precludes realistic understanding of pelagic ecosystem dynamics.

## INTRODUCTION

It has long been thought that fluctuations in year class sizes are largely dependent upon the success of fish larvae in finding necessary kinds and amounts of food (Hjort 1914). Understanding the dynamics of food webs that support fish larvae requires information not only on the kinds and amounts of food required by larval fish, but also of the organisms upon which larvae feed. Although larvae of numerous fish species, particularly clupeoids, feed directly on phytoplankton (Blaxter 1974; Lasker 1975, 1978, 1981; Mendiola 1969, 1974), most also feed upon zooplankton, at least during some stage of larval life. Since larvae of numerous species of fish may feed selectively upon certain zooplankters, which in turn may feed selectively on certain phytoplankters, there is a possibility that climatic- or anthropogenic-induced alteration of phytoplankton species assemblages may produce changes in food chain structures which extend to the top (Greve and Parsons 1977).

Since many of the thousands of zooplankton taxa present in the sea may not be directly involved in larval fish food webs, it is important to identify those zooplankters which are the food of larval fish. The feeding habits of these zooplankters must then be defined before food webs of larval fish can be understood.

This paper reviews existing knowledge of feeding habits of zooplankters that are important forage items of larval fish. These zooplankters were identified from 40 published studies inventorying the diets of 76 species of fish larvae from most oceans of the world. Eleven clupeiform, 38 perciform, 15 pleuronectiform, and 12 gadiform species were represented (Table 1). Care was taken to

use information on feeding of larvae only, not postlarvae.<sup>3</sup> All but a few studies were based on examinations of gut contents of field-caught larvae; the few exceptions were based on studies of larvae feeding upon natural zooplankton assemblages. Collette (1978), Hureau and Monod (1973), and Robins et al. (1980) were used to identify taxonomic synonymies of fish species.

Lists of fish species whose larvae have been reported to eat various zooplankton taxa are presented in Appendix Tables 1-20. For zooplankton taxa eaten by larvae of >5% of the total 76 fish species, the percentages of the total number of fish, as well as percentages of the total number from each order (Clupeiformes, Perciformes, Pleuronectiformes, and Gadiformes) that eat various zooplankters, are presented in Figures 1 and 2.

Certain geographic, size-specific, or taxon-specific patterns are apparent from these figures. For instance, the cold-water copepods *Calanus* and *Pseudocalanus* are consumed mainly by cold-water cod larvae (Gadiformes). Conversely, the apparent low utilization of the copepod genera *Corycaeus*, *Oncaea*, and *Microsetella*, which are most abundant in tropical waters, is probably a reflection of fewer studies of the feeding of tropical fish larvae than of temperate fish larvae. Although copepod nauplii are eaten by larvae of most species, and by larvae of all clupeoid species examined, they appear to be utilized much more intensively by younger (smaller) larvae. Since many clupeoid larvae are known to feed directly on phytoplankton, it is no surprise that most also eat small items such as copepod nauplii and tintinnids. Although appendicularians were eaten by only a small percentage of larvae, they were an important food for many temperate flatfish larvae (Pleuronectiformes). Further, since appendicularians are dominant zooplankters throughout the year, mainly in oceanic

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<sup>3</sup>It is clear from sizes of fish examined that Lebour's (1918, 1919, 1920) papers dealt with what we now call larvae. Apparently, larvae in her classification referred to those which still retained a yolk sac.

Table 1.—Species of fish for which the feeding habits of larvae were examined.

Species	Common name	Location <sup>1</sup>	References
Order Clupeiformes (herring-like fishes)			
<i>Anchoa mitchelli</i>	bay anchovy	FLAE	Detwyler and Houde (1970)
<i>Brevoortia patronus</i>	gulf menhaden	GOMEX	Govoni et al. (1983)
<i>Brevoortia tyrannus</i>	Atlantic menhaden	NCE	Kjelson et al. (1975)
<i>Brevoortia tyrannus</i>	Atlantic menhaden	DELE	June and Carlson (1971)
<i>Clupea harengus</i>	herring	NWECW	Bainbridge and Forsyth (1971)
<i>Clupea harengus</i>	herring	NWECW	Bjørke (1971, 1978)
<i>Clupea harengus</i>	herring	NWECW	Blaxter (1965)
<i>Clupea harengus</i>	herring	NWECW	Bowers and Williamson (1951)
<i>Clupea harengus</i>	herring	NWECW	Gamble et al. (1981)
<i>Clupea harengus</i>	herring	NWECW	Lebour (1918, 1919, 1920, 1921)
<i>Clupea harengus</i>	herring	NWECW	Ogilvie (1927)
<i>Clupea harengus</i>	herring	GOM	Sherman and Honey (1971)
<i>Clupea harengus</i>	herring	BOF	White (1977, 1980)
<i>Engraulis anchoita</i>	Argentine anchovy	ACW	Ciechomski (1967)
<i>Engraulis mordax</i>	northern anchovy	CALCW	Arthur (1976)
<i>Engraulis ringens</i>	Peru anchovy	PCW	Mendiola (1974)
<i>Harengula pensacolatae</i>	scaled sardine	FLAE	Detwyler and Houde (1970)
<i>Sardina pilchardus</i>	pilchard	NWECW	Lebour (1920, 1921)
<i>(Clupea pilchardus)</i> <sup>2</sup>			
<i>Sardinops sagax</i>	California sardine	CALCW	Arthur (1976)
<i>Sprattus sprattus</i>	sprat	NWECW	Lebour (1918, 1919, 1920, 1921)
<i>(Clupea sprattus)</i> <sup>2</sup>			
Order Perciformes (spiny-rayed fishes) <sup>3</sup>			
<i>Agonus cataphractus</i>	armed bullhead	NWECW	Lebour (1918, 1919, 1920)
<i>Ammodytes americanus</i>	sand lance	NEE	Covill (1959)
<i>Ammodytes marinus</i>	sand lance	NWECW	Ryland (1964); Wyatt (1974)
<i>Ammodytes tobianus</i>	sand lance	NWECW	Lebour (1918, 1920)
<i>(Ammodytes lanceolatus)</i> <sup>2</sup>			
<i>Auxis</i> sp.	frigate tuna	INDO	Uotani et al. (1981)
<i>Blennius gattorugine</i>	blenny	NWECW	Lebour (1918, 1919)
<i>Callionymus lyra</i>	dragonet	NWECW	Lebour (1918, 1919, 1920)
<i>Coryphoblennius galerita</i>	blenny	NWECW	Lebour (1918, 1919)
<i>(Blennius galerita)</i> <sup>2</sup>			
<i>Crystallogobius nilssonii</i>	gobi	NWECW	Lebour (1918, 1919, 1920)
<i>Ctenolabrus rupestris</i>	wrasse	NWECW	Lebour (1919, 1920)
<i>Cyclogaster montagui</i>	sea snail	NWECW	Lebour (1918, 1919)
<i>Diplecogaster bimaculatus</i>	clingfish	NWECW	Lebour (1919, 1920)
<i>(Lepadogaster bimaculatus)</i> <sup>2</sup>			
<i>Eutrigla gurnardus</i>	gurnard	NWECW	Lebour (1918, 1920)
<i>(Trigla gurnardus)</i> <sup>2</sup>			
<i>Gobius niger</i>	goby	NWECW	Lebour (1919, 1920)
<i>(Gobius paganellus)</i> <sup>2</sup>			
<i>Gobiusculus flavescens</i>	goby	NWECW	Lebour (1918, 1919, 1920)
<i>(Gobius minutus)</i> <sup>2</sup>			
<i>(Gobius ruthensparri)</i> <sup>2</sup>			
<i>Katsuwonus pelamis</i>	skipjack tuna	INDO	Uotani et al. (1981)
<i>Labrus bergylta</i>	wrasse	NWECW	Lebour (1918, 1919, 1920)
<i>Labrus bimaculatus</i>	wrasse	NWECW	Lebour (1920)
<i>(Labrus mixtus)</i> <sup>2</sup>			
<i>Lagodon rhomboides</i>	pinfish	NCE	Kjelson et al. (1975)
<i>Leiostomus xanthurus</i>	spot	NCE	Kjelson et al. (1975)
<i>Leiostomus xanthurus</i>	spot	GOMEX	Govoni et al. (1983)
<i>Lepadogaster candollei</i>	clingfish	NWECW	Lebour (1918, 1919, 1920)
<i>Lepadogaster lepadogaster</i>	clingfish	NWECW	Lebour (1918, 1919)
<i>(Lepadogaster gouani)</i> <sup>2</sup>			
<i>Micropogonias undulatus</i>	Atlantic croaker	GOMEX	Govoni et al. (1983)
<i>Myoxocephalus aeneus</i>	sculpin	NEE	Laroche (1982)
<i>Myoxocephalus</i>			
<i>octodecemspinosus</i>	sculpin	NEE	Laroche (1982)
<i>Myoxocephalus scorpius</i>	sculpin	NEE	Laroche (1982)
<i>Pomatoschistus microps</i>	goby	NWECW	Lebour (1920)
<i>(Gobius microps)</i> <sup>2</sup>			
<i>Sebastes marinus</i>	redfish	IS	Bainbridge (1965)
<i>Sebastes marinus</i>	redfish	GOM	Marak (1974)
<i>Scomber scomber</i>	mackerel	NWECW	Lebour (1918, 1920)
<i>Taurulus bubalis</i>	bullhead	NWECW	Lebour (1918, 1919, 1920)
<i>(Cottus bubalis)</i> <sup>2</sup>			
<i>Thunnus alalunga</i>	albacore	INDO	Uotani et al. (1981)
<i>Thunnus albacares</i>	yellowfin tuna	INDO	Uotani et al. (1981)



Table 1.—Continued.

Species	Common name	Location <sup>1</sup>	References
<i>Thunnus maccoyii</i>	southern bluefin	INDO	Uotani et al. (1981)
<i>Thunnus obesus</i>	bigeye tuna	INDO	Uotani et al. (1981)
<i>Trachinus vipera</i>	weaver	NWECW	Lebour (1918, 1919, 1920)
<i>Trachurus symmetricus</i>	jack mackerel	CALCW	Arthur (1976)
<i>Trachurus trachurus</i> ( <i>Caranx trachurus</i> ) <sup>2</sup>	horse mackerel	NWECW	Lebour (1918, 1919, 1920)
<i>Triglops murrayi</i>	sculpin	NEE	Laroche (1982)
Order Pleuronectiformes (flatfish)			
<i>Arnoglossus</i> sp.	lefteye flounder	NWECW	Lebour (1918, 1920)
<i>Limanda limanda</i> ( <i>Pleuronectes limanda</i> ) <sup>2</sup>	dab	NWECW	Last (1978a); Lebour (1918, 1919, 1920)
<i>Microchirus variegatus</i> ( <i>Solea variegata</i> ) <sup>2</sup>	thickback sole	NWECW	Lebour (1918, 1919)
<i>Microstomus kitt</i> ( <i>Pleuronectes microcephalus</i> ) <sup>2</sup>	lemon dab	NWECW	Lebour (1918, 1919, 1920)
<i>Phrynorhombus regius</i> ( <i>Zeugopterus unimaculatus</i> ) <sup>2</sup>	turbot	NWECW	Lebour (1918)
<i>Phrynorhombus norvegicus</i> ( <i>Scophthalmus norvegicus</i> ) <sup>2</sup>	turbot	NWECW	Lebour (1918, 1920)
<i>Platichthys flesus</i> ( <i>Pleuronectes flesus</i> ) <sup>2</sup>	righteye flounder	NWECW	Last (1978a); Lebour (1918, 1920)
<i>Pleuronectes platessa</i>	plaice	NWECW	Last (1978a); Lebour (1920); Ryland 1964; Shelbourne (1953, 1957, 1962); Wyatt (1974)
<i>Psetta maxima</i> ( <i>Rhombus maximus</i> ) <sup>2</sup>	turbot	NWECW	Lebour (1920)
<i>Pseudopleuronectes americanus</i>	winter flounder	NEE	Pearcy (1962)
<i>Scophthalmus maximus</i>	turbot	NWECW	Last (1979)
<i>Scophthalmus rhombus</i> ( <i>Rhombus laevis</i> ) <sup>2</sup>	brill	NWECW	Lebour (1919, 1920)
<i>Solea nasuta</i> ( <i>Solea lascaris</i> ) <sup>2</sup>	lemon sole	NWECW	Lebour (1918, 1919, 1920)
<i>Solea solea</i> ( <i>Solea vulgaris</i> ) <sup>2</sup>	common sole	NWECW	Last (1978a); Lebour (1918, 1919, 1920)
<i>Zeugopterus punctatus</i>	turbot	NWECW	Lebour (1918)
Order Gadiformes (cod-like fishes)			
<i>Ciliata mustela</i> ( <i>Onos mustela</i> ) <sup>2</sup>	rockling	NWECW	Lebour (1918, 1919, 1920)
<i>Gadus morhua</i>	cod	NWECW	Last (1978b); Lebour (1918); Ellertsen et al. (1981)
<i>Gadus morhua</i>	cod	GOM	Marak (1960); Syssoeva and Degtereva (1965)
<i>Melanogrammus aeglefinus</i>	haddock	NWECW	Ogilvie (1938)
<i>Melanogrammus aeglefinus</i>	haddock	GOM	Marak (1960)
<i>Merlangius merlangus</i> ( <i>Gadus merlangus</i> ) <sup>2</sup>	whiting	NWECW	Last (1978b); Lebour (1918, 1919, 1920)
<i>Merluccius merluccius</i>	hake	NWECW	Lebour (1920)
<i>Merluccius productus</i>	Pacific hake	CALCW	Sumida and Moser (1980)
<i>Micromesistius poutassou</i>	blue whiting	NWECW	Conway (1980)
<i>Molva molva</i>	ling	NWECW	Lebour (1920)
<i>Pollachius pollachius</i> ( <i>Gadus pollachius</i> ) <sup>2</sup>	pollack	NWECW	Lebour (1918, 1919, 1920)
<i>Pollachius virens</i>	coalfish	GOM	Marak (1960)
<i>Trisopterus luscus</i> ( <i>Gadus luscus</i> ) <sup>2</sup>	bib	NWECW	Last (1978b); Lebour (1918, 1919, 1920)
<i>Trisopterus minutus</i> ( <i>Gadus minutus</i> ) <sup>2</sup>	bib	NWECW	Lebour (1918, 1920)

<sup>1</sup>ACW, Argentine coastal waters; BOF, Bay of Fundy; CALCW, California coastal waters; DELE, Delaware estuarine waters; FLAE, Florida estuarine waters; GOM, Gulf of Maine; GOMEX, Gulf of Mexico coastal waters; INDO, Indian Ocean; IS, Irminger Sea; NCE, North Carolina estuarine waters; NEE, New England estuarine waters; NWECW, northwest European coastal waters; PCW, Peru coastal waters.

<sup>2</sup>Previous taxonomic synonymy.

<sup>3</sup>For the purposes of this review, five species of Order Scorpaenidae (*Myoxocephalus aeneus*, *M. octodecemspinus*, *M. scorpius*, *Sebastes marinus*, and *Triglops murrayi*) are included with the perciforms, since their larvae are morphologically and ecologically "perciform-like."

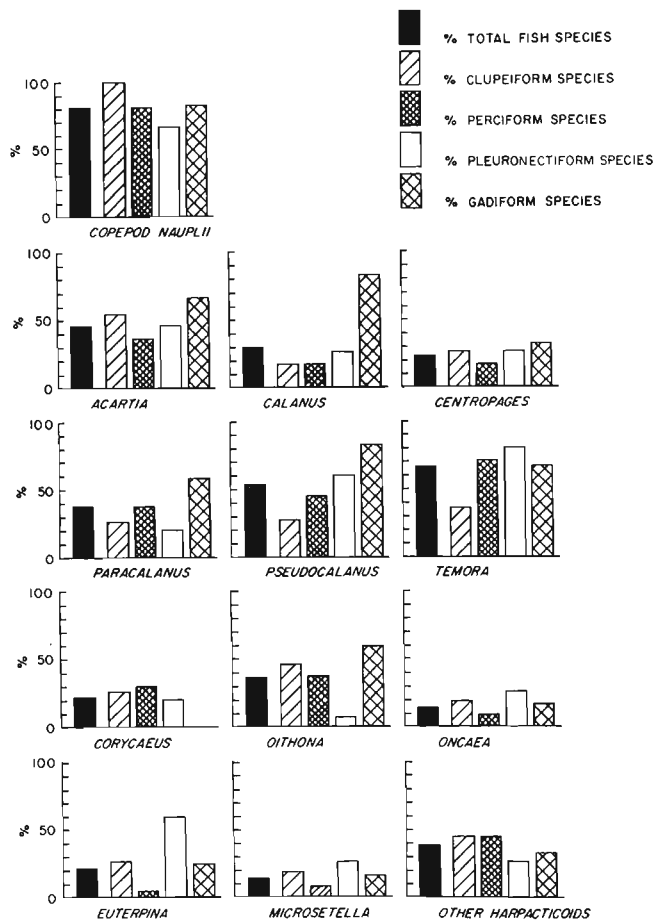


Figure 1.—Percentages of the total number of fish larvae (76 species), the total number of clupeiform larvae (11 species), the total number of perciform larvae (38 species), the total number of pleuronectiform larvae (15 species), and the total number of gadiform larvae (12 species), listed in Table 1, that have been reported to feed upon various copepod taxa.

waters, it is understandable that they were important prey items for oceanic tuna larvae (Perciformes).

Aside from such specific patterns, it is clear that the zooplankton taxa shown in Figures 1 and 2 are eaten by larvae of a variety of fish species in numerous localities. These zooplankters include adults and/or copepodites of six genera of calanoid copepods (*Acartia*, *Calanus*, *Centropages*, *Paracalanus*, *Pseudocalanus*, and *Temora*), adults and/or copepodites of three genera of cyclopoid copepods (*Corycaeus*, *Oithona*, and *Oncaea*), and adults and/or copepodites of two genera of planktonic harpacticoid copepods (*Euterpina* and *Microsetella*). Also included are zooplankton often unidentified, such as harpacticoids, copepod nauplii (some of which were identified to genus, but most not), tintinnids, the cladocerans *Evadne* and *Podon*, barnacle nauplii, gastropod larvae, the pteropod *Limacina*, and appendicularians. However, with the exception of the appendicularians which were not identified in the study of Uotani et al. (1981), the other records for appendicularians refer to *Oikopleura dioica* and *Fritillaria borealis*.

The remainder of this review will summarize published knowledge of feeding habits of the zooplankton taxa listed above.

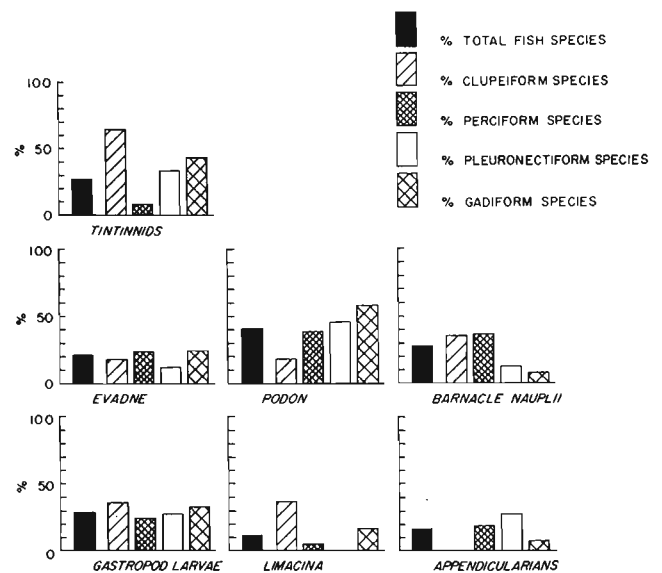


Figure 2.—Percentages of the total number of fish larvae (76 species), the total number of clupeiform larvae (11 species), the total number of perciform larvae (38 species), the total number of pleuronectiform larvae (15 species), and the total number of gadiform larvae (12 species), listed in Table 1, that have been reported to feed upon various noncopepod taxa.

## ACARTIA

*Acartia* is a broadly distributed copepod genus (Bradford 1976). In most estuarine waters of the world one or more *Acartia* species are numerically co-dominant, if not the dominant, copepods (see references cited in Turner 1981).

*Acartia* is omnivorous. Early gut content studies reveal remains of diatoms, dinoflagellates, radiolarians, and crustaceans (Lebour 1922; Marshall 1949; Conover 1956). Numerous laboratory studies have shown that various species of *Acartia* feed upon unialgal or mixed cultures of diatoms, dinoflagellates, microflagellates, coccolithophorids, and other phytoplankton (Gauld and Rayment 1953; Conover 1956, 1960; Anraku and Omori 1963; Anraku 1964a, b; Marshall and Orr 1966; Esaias and Curl 1972; Gaudy 1974; Corkett and Zillioux 1975; Nival and Nival 1976; O'Connors et al. 1976; Piontkovskii and Petipa 1976; Reeve and Walter 1977; Dagg 1977; Roman 1977; Honjo and Roman 1978; Tomasini and Mazza 1978; Donaghay and Small 1979a, b; White 1979; Deason 1980a, b; Rosenberg 1980; White 1981; Cahoon 1981; Bartram 1981; Tomas and Deason 1981; Weiss 1983).

*Acartia* is also capable of carnivorous feeding. Various species of *Acartia* eat their own juveniles (Conover 1956; Roman 1977; Landry 1978; Lonsdale et al. 1979), nauplii of other copepod species (Hodgkin and Rippingale 1971; Rippingale and Hodgkin 1975; Lonsdale et al. 1979; Lonsdale 1981), *Artemia* nauplii<sup>4</sup> (Conover 1960; Anraku and Omori 1963; Gaudy 1974), juvenile chaetognaths (Davis 1977), and tintinnids (Turner and Anderson in press; Robertson 1983).

<sup>4</sup>The use of *Artemia* nauplii as prey in experiments on predation by marine zooplankton is artificial since *Artemia* is absent from the ocean. References to such studies will be included, however, since ingestion of *Artemia* nauplii is the only evidence of feeding upon animal prey by some marine zooplankters.

In addition to eating phytoplankton and zooplankton, *Acartia* eats other items. Friedman (1980) presented electron microscopic evidence that *A. tonsa* can ingest bacteria as small as 0.5  $\mu\text{m}$  in diameter. It can also ingest particulate macrophyte detritus, but does not survive well on this diet (Roman 1977). *Acartia negligens* collected near coral reefs ingested and assimilated up to 50% of the organic matter in mucus produced by scleractinian corals (Richman et al. 1975).

The few attempts to compare the relative importance of plant and animal food for *Acartia* have produced mixed results. Anraku and Omori (1963) found that *A. tonsa* ate equal amounts of *Artemia* nauplii and the diatom *Thalassiosira fluviatilis*. However, Gaudy (1974) reported that *A. clausi* exhibited a marked preference for phytoplankton over *Artemia* nauplii. Lonsdale et al. (1979) demonstrated that the rates of predation by *A. tonsa* adults on conspecific nauplii and nauplii of other copepods were not reduced by the presence of alternative phytoplankton food.

There is also disagreement on the selective feeding of *Acartia* on particles. Although many studies have suggested size-selective grazing upon the largest available cells in algal cultures, recent studies of the feeding of *Acartia* on naturally occurring particulate assemblages (Hargrave and Geen 1970; Richman et al. 1977; Poulet 1978; Mayzaud and Poulet 1978; Roman and Rublee 1980; Ryther and Sanders 1980; Bartram 1981; Turner and Anderson 1983) have produced contradictory results. Richman et al. (1977) found that *A. tonsa* and *A. clausi* preferentially fed upon the largest available particles, even if these were not the most abundant. However, as these larger particles were grazed down, grazing pressure shifted to biomass peaks of smaller sized particles. Poulet (1978) and Mayzaud and Poulet (1978) concluded that *A. clausi* was an opportunistic grazer on particles between 1.5 and 150  $\mu\text{m}$  equivalent spherical diameter, and feeding was nonselective with regard to particle size. As in the study of Richman et al. (1977), Poulet (1978) reported that grazing *A. clausi* tracked biomass peaks. Turner and Anderson (1983) found that in terms of filtration rate, *A. hudsonica* (= *A. clausi*) was unselective when feeding upon combinations of naturally occurring concentrations of a small dinoflagellate (*Heterocapsa triquetra*) and a larger dinoflagellate (*Gonyaulax tamarensis*), or *G. tamarensis* and tintinnids. Each type of food was eaten in approximate proportion to its availability. Ryther and Sanders (1980) examined the feeding of *A. tonsa* on natural particulate assemblages in large-volume continuous-flow enclosures and reported that *A. tonsa* reduced the number of centric diatoms (mainly *Skeletonema costatum*) by 10% in grazed enclosures, but that small flagellates increased by 35-60%. Presumably this occurred because, as suggested by Conover (1956), *Acartia* is an inefficient grazer of small flagellates, and these increased in the grazed enclosures due to reduced nutrient competition with diatoms.

Other studies suggest that some flagellates are poor food for *Acartia*. Tomas and Deason (1981) offered *A. hudsonica* and *A. tonsa* cultures of the diatom *Skeletonema costatum* and the flagellates *Dunaliella tertiolecta* and *Olisthodiscus luteus*, either singly or in combination. At intermediate and high concentrations, *O. luteus* was inhibitory to feeding, both on itself and on the other phytoplankters. Also, Parrish and Wilson (1978) found that *A. tonsa* females produced eggs equally well on diets of the diatom *Thalassiosira pseudonana* or the "large" (100-140  $\mu\text{m}^3$ ) flagellate *Chroomonas salina*, but that when the small flagellate *Isochrysis galbana* (40  $\mu\text{m}^3$ ) was the only food, egg production ceased, as with starved females, after 3 d.

These observations are somewhat at odds with the results of *Acartia* culture studies. Flagellates such as *Isochrysis galbana*, *Dunaliella tertiolecta*, and *Platymonas succia* have been used as food (usually in combination with diatoms) to rear multiple generations of *A. tonsa*, *A. clausi*, or *A. steueri* from fertilized egg to adult (Zillioux and Wilson 1966; Heinle 1969, 1970; Zillioux 1969; Nassogne 1970; Uye 1980a, b, 1981; Tester 1982). However, Klein Breteler (1980) successfully cultured *A. clausi* only when dinoflagellates were added as food, not when microflagellates alone were used. These discrepancies possibly reflect the suitability of small flagellates as food for *Acartia* nauplii, but additional diatom or dinoflagellate food is needed for late copepodite and adult stages of *Acartia*.

Earlier observations of the feeding mechanisms of *Acartia* (Conover 1956; Gauld 1966), supplemented by recent cinematographic studies (Rosenberg 1980), revealed that the feeding mechanisms of *Acartia* are complex. Other observations suggest the possibility of chemosensory detection of food. For instance, Poulet and Marsot (1978) found that microcapsules enriched with homogenate of naturally occurring phytoplankton were ingested preferentially over nonenriched capsules by *A. clausi*. Lonsdale et al. (1979) found that predation rates by *A. tonsa* adults on nauplii of three other copepod species were significantly higher than cannibalism of conspecific nauplii. This suggests that *Acartia tonsa* adults can recognize conspecific nauplii, relative to those of other species.

The abundance of *Acartia* in food-rich inshore, particularly estuarine, environments may relate largely to its feeding ecology. Dagg (1977) found that *A. tonsa* needed fairly continuous food for survival and egg production. *Acartia tonsa* starved within 6-10 d with no or only intermediate additions of food, whereas other co-occurring copepod species survived for up to 20 d under constant starvation. Dagg concluded that *Acartia* is less well equipped than other copepod species to overcome periods of poor food conditions and subsequently exploit food-rich patches when they occur. However, in continuous food-rich conditions, such as estuaries, *Acartia* can outcompete other species due to its elevated fecundity.

## CALANUS

It has long been known that species of the genus *Calanus* are omnivorous. Gut contents of North Atlantic *C. finmarchicus* contain remains of diatoms, dinoflagellates, silicoflagellates, *Phaeocystis*, coccolithophorids, radiolarians, tintinnids, molluscan larvae, and other crustaceans (Dakin 1908; Lebour 1922; Marshall 1924). Marshall (1924) found that the food remains in any single gut were mixed, that seasonal changes in gut contents reflected seasonal changes in the microplankton upon which the copepods fed, and that no particular preference was shown for any given species of phytoplankton. Guts of Pacific *C. tenuicornis*, *C. plumchrus*, and *C. cristatus* also contain diatom, coccolithophorid, silicoflagellate, tintinnid, and foraminiferan remains (Gienrikh 1958; Arashkevich 1969).

Numerous studies have shown that various species of *Calanus* eat a variety of cultured phytoplankton diets (Clarke and Gelliss 1935; Fuller and Clarke 1936; Fuller 1937; Harvey 1937; Clarke and Bonnet 1939; Gauld 1951; Marshall and Orr 1952, 1955a, b, 1958, 1961; Conover 1960, 1966a, b, c; Mullin 1963; Anraku and Omori 1963; Anraku 1964a; Corner et al. 1967, 1972; Butler et al. 1969; Richman and Rogers 1969; Paffenhöfer and Strickland 1970; Paffenhöfer 1971, 1976a, b; Esaias and Curl 1972; Frost 1972, 1975, 1977; Gaudy 1974; Dagg 1977; Ikeda 1977; Schnack

1979, 1983; Vidal 1980a, b; Runge 1980; Gifford et al. 1981; Cox and Willason 1981; Huntley 1982). Other studies have examined the filter feeding of *Calanus* on natural particulate assemblages (Corner 1961; Cowey and Corner 1963; Adams and Steele 1966; Butler et al. 1970; McAllister 1970; Ikeda 1971; Taguchi and Ishii 1972; Gamble 1978; Cowles 1979; Hebert and Poulet 1980; Dagg et al. 1980, 1982; Boyd et al. 1980; Huntley 1981, 1982; Harris 1982). Additionally, *C. helgolandicus* and *C. pacificus* (possibly the same species) have been cultured on phytoplankton diets (Mullin and Brooks 1970a, b; Paffenhöfer 1970; Vidal 1980a, b).

Many concepts of copepod feeding that have risen to the status of paradigms are based upon experiments with *Calanus*. For instance, the concept that copepods preferentially select larger sized phytoplankton cells began as a result of Harvey's (1937) experiments with *C. finmarchicus*. Harvey fed the copepods on mixtures of large and small diatoms, and found that invariably more of the larger cells were eaten. Richman and Rogers (1969) reported that *C. helgolandicus* filtered significantly higher numbers of paired daughter cells (after cell division, but before final separation) of the diatom *Ditylum brightwelli*, than unpaired cells. Since the same species was offered, and the only difference was in terms of size rather than nutritional content, Richman and Rogers concluded that their results demonstrated size-selective feeding. Frost (1977) found that *C. pacificus*, presented with different-sized cells of the same diatom species, invariably ate large cells at a higher rate than small ones. Frost concluded that this differential filtration of cells of different sizes was purely mechanical and a function of variable retention efficiency of the intersetular distances of the filtering appendages (second maxillae) of the copepods. The results of Gamble (1978) support the notion of size-selective feeding on larger particles, in that *C. finmarchicus* mainly filtered the largest available cells, which were also the most abundant, during a spring diatom bloom in the North Sea. *Calanus* may also preferentially feed on chain-forming or spine-bearing diatoms because they occupy a larger volume and are more frequently encountered. Schnack (1979) fed *C. helgolandicus* on mixtures of chain-forming diatoms, and found that grazing was most intense upon species which had long spines. Gifford et al. (1981) obtained the same result using *C. finmarchicus*.

The results of some recent studies of *Calanus* feeding upon natural particulate assemblages often do not point to size-selective feeding. Cowles (1979) found that *C. chilensis* in the Peru upwelling were size-selective grazers at high food concentrations, but became less selective as total food concentration declined. Also, the size spectrum of particles ingested was much broader at low than at high food concentrations. Cowles concluded that while the mechanical sieve mechanism of filtering (Boyd 1976; Frost 1977) could explain the patterns recorded at high food concentrations, it could not explain the diet expansion at low food levels. Similarly, Harris (1982) found that *C. pacificus* grazed a broad size spectrum of phytoplankton, similar to that grazed by the much smaller copepod *Pseudocalanus*. Harris concluded that both species compete for the same food resource over a wide range of the particle-size spectrum. Hunger of animals also appears to influence size selection. Runge (1980) found differences in filtration rate versus cell size relations for starved versus well-fed *C. pacificus*.

The question of size-selective feeding by *Calanus* and other copepods is still unresolved. Inasmuch as laboratory studies using phytoplankton cultures as food allow reliable quantification of grazing on distinct size classes of food, they have the disadvantage of not offering copepods the broad size spectrum and nutritional

array encountered in nature. Thus, because experimental conditions are partly artificial, patterns recorded may have questionable relevance to copepod behavior in nature. Feeding studies using natural particulate assemblages have the advantage of presenting animals with a food array found in nature. Unfortunately most such recent studies have quantified particle number and size by using electronic particle counters. Harbison and McAlister (1980) demonstrated numerous artifacts which can result from using electronic particle counters to quantify natural particle assemblages. They concluded that many reported patterns of copepod feeding resulting from such studies are not based upon experimental evidence.

The study of Huntley (1981) represents one of the few attempts to define copepod feeding upon natural particulate assemblages in which particle quantification was performed by visual rather than electronic means. Huntley found that three species of *Calanus* from the Labrador Sea exhibited no selective feeding on various phytoplankton species ( $>20 \mu\text{m}$  cell diameter) on the basis of size, shape, or species of cell. The copepods removed various phytoplankters in direct proportion to their abundance.

Another copepod feeding paradigm based on experiments with *Calanus* is that of the maximum ingestion rate plateau. Frost (1972) fed monospecific diatom cultures at different cell concentrations to adult female *C. pacificus* and found that the ingestion rate increased linearly with increasing food concentration up to a maximum rate, beyond which the ingestion rate remained constant with increasing levels of food. This maximum ingestion rate (saturation) was the same, in terms of carbon, for diatoms ranging in diameter from 11 to 87  $\mu\text{m}$ , but as cell size increased the carbon concentration at which saturated feeding was achieved decreased. Frost (1972) concluded that *C. pacificus* can obtain their maximum daily ration at lower carbon concentrations when feeding on larger cells.

Conover (1978b) suggested that saturated feeding is likely an artifact of unnaturally high laboratory food concentrations, and concluded that food concentrations in nature are rarely, if ever, high enough to induce saturation. This view is supported by experiments of Reeve and Walter (1977) with *Acartia tonsa*, and Huntley (1981) with *Calanus*. Huntley found no evidence of a saturated ingestion rate for three *Calanus* species feeding on the spring diatom bloom in the Labrador Sea. Although Runge (1980) did record saturated feeding rates by *C. pacificus*, he found that there are seasonal changes in the level of food at which saturation is obtained.

*Calanus* also exhibits carnivorous feeding. Various species eat their own eggs (Conover 1960, 1966a), *Artemia* nauplii (Anraku and Omori 1963; Gaudy 1974), barnacle nauplii (Corner et al. 1974, 1976), and the nauplii of other species of copepods (Landry 1980, 1981). *Calanus finmarchicus* appeared to prefer phytoplankton over *Artemia* nauplii in the studies of Anraku and Omori (1963) and Gaudy (1974), but Landry (1981) found that *C. pacificus* can switch from eating diatoms to copepod nauplii, eating primarily whatever is most abundant.

Other food items eaten by *Calanus* include fecal pellets and other forms of detritus (Paffenhöfer and Strickland 1970). Paffenhöfer and Knowles (1979) reared *C. helgolandicus* from copepodite stage III to adult on a diet of fecal pellets alone. Boyd et al. (1980) found that *C. chilensis* in the Peru upwelling also appeared to utilize nonliving detrital particulates as a major component of its diet. Additionally, *C. helgolandicus* has been shown to eat "red mud" (microscopic particles of  $\text{Fe}_2\text{O}_3$  residual from extraction of aluminum from bauxite), but the copepod does not

survive or feed well upon diatoms in the presence of "red mud" (Paffenhöfer 1972).

Although ingestion of nonnutritional particles such as "red mud" suggests that *Calanus* cannot discriminate between different food items, there is also limited evidence to suggest that a choice may occur. Huntley (1982) found that *C. pacificus* filtration rates on a large dinoflagellate during a red tide were minimal compared with those when a small diatom was used as food. He concluded that the persistence of the bloom may have been partly due to a lack of grazing, and that the dinoflagellate was likely avoided by the copepods.

Although some phytoplankton blooms may not be grazed because their component species are repulsive to copepods, other blooms may develop because of a lag in copepod feeding response. Cox and Willason (1981) found that production of the digestive enzyme laminarinase by *C. pacificus* requires presence of the substrate laminarin (the principal storage product of marine phytoplankton). Since there was at least a 1 d lag in the production of the enzyme in the copepods after addition of substrate, Cox and Willason proposed that such a time lag may be important in areas of bloom potential, since the lag would allow initial development of a bloom before it could be destroyed by grazing.

The role of *Calanus* and other copepods in cropping primary production has long been of interest (Harvey et al. 1935; Riley 1946; Cushing 1958, 1964; Cushing and Vucetic 1963; Dagg and Turner 1982) and, as expected, the impact of grazing has varied. Dagg et al. (1980) found that *C. chilensis* and two other large copepods consumed <5% of the daily carbon production in the Peru upwelling. Dagg et al. (1982) found that three large copepods (*Eucalanus bungii*, *Calanus (Neocalanus) cristatus* and *C. (N.) plumchrus*) removed 6-25% of the daily primary production during the spring bloom in the Bering Sea. Dagg and Turner (1982) found that during the spring bloom in the New York Bight and Georges Bank areas a copepod community dominated by *C. finmarchicus* and *Pseudocalanus* grazed 15-48% of the daily primary production. In both areas, grazing impact was highest on the outer shelf (30-48% of primary production) because of large populations of *C. finmarchicus*. In other regions, grazing appears particularly important. Frost (1980) stated that the lack of seasonal variation in the phytoplankton biomass of the subarctic North Pacific, where phytoplankton apparently never reach bloom concentrations even though conditions favorable to blooming do occur, is largely due to continuous grazing by subadults of *C. (N.) plumchrus* and *C. (N.) cristatus*. Since adults of these species do not feed, reproduction is not dependent upon phytoplankton pulses, and large numbers of juvenile copepods are present in the epipelagic waters during the season when phytoplankton blooms should occur.

Frost et al. (1983) confirmed that *Calanus (Neocalanus) cristatus* and *C. (N.) plumchrus* CV copepodites could feed on the low concentrations of small phytoplankton cells found in the subarctic Pacific. In addition, these copepodites exhibited predatory feeding upon copepodites of the small copepod *Oithona similis*.

In conclusion, it appears that species of *Calanus* are omnivorous, in that they are capable of carnivorous as well as herbivorous feeding. However, it is likely that this genus is primarily and broadly herbivorous, resorting to carnivory mainly during periods of phytoplankton paucity (Corner et al. 1974; Digby 1954).

## CENTROPAGES

Members of the genus *Centropages* are broadly omnivorous. Gut

contents have included remains of diatoms, dinoflagellates, coccolithophorids, tintinnids, copepods, and molluscan larvae (Lebour 1922; Marshall 1924, 1949; Marshall and Orr 1966). Cultured phytoplankton diets have been fed to *C. hamatus* (Kiørboe et al. 1982; Marshall and Orr 1966; Gauld 1951; Gauld and Raymont 1953; Smith and Hall 1980; Klein Breteler 1980), *C. typicus* (Cowles and Strickler 1983; Gaudy 1974; Dagg 1977, 1978; Tomasini and Mazza 1978; Smith and Hall 1980), and *C. furcatus* (in the Atlantic = *C. velificatus* — see Fleminger and Hulsemann, 1973) (Paffenhöfer and Knowles 1980). *Centropages* is also capable of carnivorous feeding (Anraku and Omori 1963; Gaudy 1974; Paffenhöfer and Knowles 1980; Conley 1983).

There is a lack of consensus on the relative importance of plant and animal food in *Centropages* diets. Anraku and Omori (1963) examined the feeding responses of *C. hamatus* and *C. typicus* on diets of *Artemia* nauplii and diatoms, either singly or in combination. Both species of *Centropages* ate both types of food, but animal food (*Artemia*) was preferred. However, Gaudy (1974) found that *C. typicus* fed equally well on *Artemia* nauplii and phytoplankton cultures. Paffenhöfer and Knowles (1980) found that the subtropical species, *C. velificatus*, ingested a higher percentage of its body nitrogen as copepod nauplii (laboratory-reared *Pseudodiaptomus coronatus*) than as unialgal phytoplankton (*Rhizosolenia*). Conversely, Conley (1983) found that the temperate species, *C. hamatus*, ingested a higher proportion of its body carbon as natural estuarine phytoplankton (predominantly small flagellates) than as cooccurring wild copepod nauplii (primarily *Acartia hudsonica* or *A. tonsa*). Such differences may reflect the use of different food sources, different experimental procedures and methods of measurement, or possibly real differences between subtropical continental shelf (*C. velificatus*) and temperate estuarine (*C. hamatus*) species.

There have been few investigations of the grazing of *Centropages* on natural particulate matter. Dagg and Grill (1980) found that ingestion rates of *C. typicus* in the New York Bight were usually less than maximal, and concluded that ingestion rates were closely related to food quality because of the narrow range of available food concentrations. Dagg et al. (1980) calculated that in the Peru upwelling the population of *Centropages brachiatus* consumed an average of 1.5  $\mu\text{gC}/\text{m}^2$  per d. Since average primary production rates were >1  $\text{gC}/\text{m}^2$  per d, Dagg et al. calculated that the grazing stress of *C. brachiatus* and two other large copepods (*Eucalanus inermis* and *Calanus chilensis*) was always < 5% of the daily carbon production. Cowles (1979) examined the feeding responses of the same three species of copepods in the Peru upwelling. He found that *C. brachiatus* was a size-selective grazer at high food concentration, and exhibited decreased selectivity as total food level declined.

Boyd et al. (1980) found that in the Peru upwelling *C. brachiatus* migrated into the food-rich upper 5 m at night, but did not show a migration pattern when food was scarce. Using gut fluorescence techniques, Boyd et al. found no indication that *C. brachiatus* was grazing phytoplankton in proportion to its abundance, and concluded that this reflected predatory feeding in addition to grazing.

As with *Acartia tonsa*, Dagg (1977) found that *C. typicus* is intolerant of starvation and intermittent food. He concluded that *C. typicus* is therefore sensitive to small-scale patchiness. The migration data of Boyd et al. (1980) support this proposal, in that *C. brachiatus* actively moved into food-rich waters. Their data also support other observations suggesting that carnivory is a major component of *Centropages* ecology.

## PARACALANUS

Limited available literature suggests that small (< 1 mm adult body length) copepods of the genus *Paracalanus* are primarily herbivorous. Lebour (1922) found diatom and coccolithophorid remains in the guts of *P. parvus*, and several *Paracalanus* species have been fed phytoplankton cultures or natural particulate assemblages (Marshall and Orr 1966; Ikeda 1977; Checkley 1980; Bartram 1981; Price et al. 1983). Bartram (1981) showed that *P. parvus* was more efficient at capturing small particles than was *Acartia*, and that *P. parvus* fed at a higher rate on small particles. Sorokin et al. (1970) stated that *P. parvus* can also filter bacteria.

The calculations of Paffenhöfer (1982) indicate that *Paracalanus* can have a substantial grazing impact on natural systems. Applying his own grazing rates for *Paracalanus* sp. from the southeastern shelf of the United States to the numbers of *Paracalanus denudatus* reported by Dagg et al. (1980) in the Peru upwelling, Paffenhöfer calculated that *Paracalanus* could graze an average of 33% of the primary production in the Peru upwelling.

## PSEUDOCALANUS

Corkett and McLaren (1978:54-80) reviewed feeding studies published prior to 1977, which showed that *Pseudocalanus* is mainly a filter feeder, ingesting a variety of diatom, coccolithophorid, flagellate, and radiolarian foods. However, Marshall (1949) found crustacean remains in *Pseudocalanus* guts, and Corkett and McLaren (1978) stated that females will cannibalize their own nauplii. *Pseudocalanus* also ingests detrital particles (Poulet 1976). Nonetheless, Corkett and McLaren concluded that *Pseudocalanus* is overwhelmingly herbivorous. This conclusion is supported by culture studies of Paffenhöfer and Harris (1976) and Vidal (1980a). In both cases, *Pseudocalanus* was cultured from fertilized eggs to adults on diatom diets.

Recent studies of grazing on natural particulate assemblages (Poulet 1978; Koeller et al. 1979; Harris 1982) reveal that *Pseudocalanus* ingests a broad spectrum of particle sizes. Poulet (1973, 1974, 1978) reported seasonal shifts of grazing on the most abundant particles, regardless of size, and concluded that *Pseudocalanus* is an unselective opportunistic grazer. Harris (1982) found that *Pseudocalanus* grazed a size spectrum of phytoplankton similar to that grazed by *Calanus*, which is 10 times larger in terms of body weight.

Dagg (1977) found that *Pseudocalanus* can withstand starvation for at least 16 d, and can produce eggs under discontinuous starvation at rates equivalent to those for continuously fed animals. Dagg concluded that *Pseudocalanus* can metabolically remove itself from poor food conditions and wait for food-rich patches. Vidal (1980a) demonstrated that the growth rate of *Pseudocalanus* is relatively insensitive to food concentration. Vidal concluded that this contributes to survival fitness of *Pseudocalanus* in adverse conditions which frequently occur in its temperate and boreal habitat.

## TEMORA

Early gut content studies (Lebour 1922; Marshall 1949) revealed that *Temora* is omnivorous, eating diatoms, dinoflagellates, the haptophycean *Phaeocystis*, radiolarians, and other crustaceans. Gauld (1966) stated that *Temora* is a filter feeder that also feeds as a grasping predator.

Numerous studies show that the temperate species *Temora longicornis* eats a variety of cultured phytoplankton diets (Gauld 1951, 1953; Gauld and Raymont 1953; Raymont 1959; Conover 1959; Marshall and Orr 1966; Berner 1962; Harris and Paffenhöfer 1976a; Cushing 1958; Smith and Hall 1980; Schnack 1983; Weiss 1983). Studies reaching similar conclusions for the subtropical/tropical species *T. turbinata* and *T. stylifera* include those of Gaudy (1974), Ikeda (1977), and Paffenhöfer and Knowles (1978, 1980). *Temora longicornis* has also been cultured from fertilized egg to adult on various flagellate or diatom diets (Corkett 1967, 1970; Corkett and Zillioux 1975; Harris and Paffenhöfer 1976a; Klein Breteler 1980).

Studies of grazing of *Temora* on natural particulate assemblages have had inconsistent results. Hargrave and Geen (1970) found that *T. longicornis* ate all sizes of flagellates present in natural estuarine water, and that feeding rates were highest on larger cells, even though smaller cells were most abundant. They also reported that *T. longicornis* did not eat chain-forming diatoms of the genus *Chaetoceros*, or other chain-formers, even though these were the numerically dominant phytoplankters. This seems peculiar, since Harris and Paffenhöfer (1976a) have cultured the same copepod on unialgal diets of chain-forming diatoms, and Gaudy (1974) and Paffenhöfer and Knowles (1978) demonstrated that *T. stylifera* and/or *T. turbinata* ate a variety of chain-forming diatoms.

Poulet (1978) and Mayzaud and Poulet (1978) reported that *T. longicornis* feeding on natural particles was an opportunistic grazer, and nonselective with regard to particle size. Mayzaud and Poulet (1978) also found that ingestion rate was linear with increasing food concentration, regardless of particle size. In a similar study with *T. longicornis* feeding on natural particles, O'Connors et al. (1980) found that different ingestion rate versus food concentration relations emerged when the food particle assemblage had differences in species composition and size distribution. Maximum ingestion rates were higher when *T. longicornis* fed upon larger sized chain-forming diatoms than on naked microflagellates.

*Temora* is also capable of carnivorous feeding. Various species eat corpses of other copepods (Lowndes 1935), their own eggs (Gaudy 1974), *Artemia* nauplii (Gaudy 1974), and the nauplii of other copepods (Paffenhöfer and Knowles 1980). Although Gaudy (1974) found that *T. stylifera* had a higher food intake when feeding on *Artemia* nauplii than when feeding on various phytoplankton cultures, Paffenhöfer and Knowles (1980) found that *T. stylifera* ingested more food as phytoplankton than as nauplii of another copepod.

In addition to phytoplankton and zooplankton foods, *T. longicornis* has ingested oil particles following a tanker wreck, with no apparent ill effect (Conover 1971). Also, Paffenhöfer and Knowles (1979) found that *T. stylifera* ate fecal pellets of the nauplii of another copepod at about the same rate as it ate large phytoplankton cells (*Rhizosolenia*) having cell volumes comparable with those of small fecal pellets.

## CYCLOPOID COPEPODS

### *Oithona*

There is limited information on the feeding habits of several species of *Oithona*, and much of it is contradictory. Taken as a whole, however, members of the genus apparently are omnivorous.

Lebour (1922) concluded that *O. similis* is primarily herbivorous after finding diatom remains in its gut. Murphy (1923) cultured *O. nana* on pieces of ground kelp, although she stated that the guts of field-caught specimens contained diatom and copepod remains. Gauld (1966) and Marshall and Orr (1966) stated that *O. similis* feeds little on phytoplankton, and then only on large cells. Since Gauld (1966) and Marshall and Orr (1966) found that *O. similis* eats the nauplii of other copepod species, they concluded that the species is primarily carnivorous. Timonin (1969, 1971) reached the same conclusion for several other species of *Oithona*. However, Petipa et al. (1970) considered *Oithona* copepodites to be omnivorous and only adults to be exclusively carnivorous.

*Oithona nana* can eat either *Acartia* or *Calanus* nauplii (Lampitt 1978; Lampitt and Gamble 1982), but it can also ingest unialgal cultures of five phytoplankton species ranging in size from 2.7 to 67.0  $\mu\text{m}$  in diameter (Lampitt and Gamble 1982). Likewise, Hargrave and Geen (1970) and Poulet (1978) found that *O. similis* fed upon natural particulate assemblages and ingested various phytoplankton species, but Poulet suggested that *O. similis* may be an inefficient grazer. This may partly explain why Dagg and Turner (1982) calculated that a copepod community dominated by *O. similis* was grazing > 100% of the primary production/day in continental shelf waters. Nonetheless, diets consisting solely of phytoplankton cultures have been used to rear *O. nana* (Haq 1965) and *O. colcarva* (Lonsdale 1981).

### *Corycaeus*

Little is known of the feeding habits of *Corycaeus*. Lebour (1922) found remains of diatoms, dinoflagellates, and coccolithophorids in *C. anglicus* guts, and she classified this species as primarily herbivorous. Wickstead's (1962) examination of preserved Indo-Pacific species of *Corycaeus* led him to conclude that they were mainly carnivorous. Timonin (1969, 1971) also classified the genus as carnivorous. Indeed, Gophen and Harris (1981) found that *C. anglicus* ate *Artemia* nauplii, and Johnson (1969 — cited in Gibson and Grice 1978) classified this species as a raptorial carnivore with *Acartia* spp. as primary prey. Nonetheless, Landry and Zakar (unpubl. data — cited in Landry 1981) found that stomachs of *C. anglicus* may be full of phytoplankton during bloom conditions.

### *Oncaea*

The feeding habits of all species of the genus *Oncaea* are largely a matter of conjecture. Gienrikh (1958) mentioned that *O. conifera* guts contain coccoliths and remains of pennate diatoms, but Wickstead (1962) classified the genus as carnivorous. Bernard (1963a) and Wickstead (unpubl. data) (both cited by Marshall 1973) hypothesized that *Oncaea* is actually a temporary plankter, and that it either feeds in bottom sediments (Bernard) or attaches to, and feeds upon, gelatinous zooplankton (Wickstead). While there are little data to support the hypothesis that *Oncaea* is not truly holoplanktonic, Alldredge (1972) found that *Oncaea mediterranea* can feed upon abandoned appendicularian houses and the microplankton attached to them.

## PLANKTONIC HARPACTICOID COPEPODS

Many species of harpacticoids inhabit epibenthic or meiobenthic habitats, and it is likely that benthic harpacticoids are a major portion of the "unidentified harpacticoid" component of the diets

of demersal larvae of many fishes. Some benthic harpacticoids have been cultured (Omori 1973; Walker 1981) on a variety of phytoplankton diets. In addition, feeding studies reveal that certain species ingest phytoplankton, protozoans, detritus (Harris 1977; Heinle et al. 1977; Brown and Sibert 1977; Rieper and Flotow 1981), and bacteria (Rieper 1978, 1982; Brown and Sibert 1977).

Information on the feeding habits of planktonic harpacticoids is sparse. Lebour (1922) found phytoplankton and copepod remains in the guts of *Euterpina acutifrons*. This species has also been cultured on a variety of unialgal or mixed phytoplankton cultures (Bernard 1963b — cited in Omori 1973; Haq 1972; Nassogne 1970; Neunes and Pongolini 1965; Zurlini et al. 1978). The only information located on feeding by *Microsetella* is that *M. rosea* guts contain coccoliths, green remains, and radiolarian spines (Gienrikh 1958). Bjornberg (1965) found that *Macrosetella gracilis* requires the blue-green alga *Trichodesmium* as a substrate. Roman (1978) confirmed this, and found that *M. gracilis* ingested *Trichodesmium* at rates equivalent to 90-126% of its body weight/day.

## COPEPOD NAUPLII

All copepods, regardless of adult body size, begin life as small nauplii. Copepods molt through six progressively larger naupliar stages, followed by six copepodite stages, the sixth being the adult. Although subadult copepods usually outnumber adults by orders of magnitude in most marine waters (for example, compare numbers in Turner 1982), the feeding habits of these juveniles, particularly nauplii, are poorly known. Intuitively one might expect that copepod nauplii eat smaller phytoplankton cells than adults, but this is not always the case.

Marshall and Orr (1956) fed *Calanus finmarchicus* nauplii on cultures of small flagellates, coccolithophorids, chain-forming diatoms, and dinoflagellates. Smaller naupliar stages usually did not eat smaller sized cells than did larger naupliar stages. Rather, some stages of nauplii ate the same types and sizes of food as adults. Marshall and Orr found that naupliar stages I and II did not feed, presumably because their anus had not yet formed. From naupliar stage III onward, cells of up to 20  $\mu\text{m}$  in diameter were eaten, but flagellates as small as 2-4  $\mu\text{m}$  in diameter were not eaten.

Nauplii of other copepod species do not always exhibit these same patterns. Mullin and Brooks (1967) found that *Rhincalanus nasutus* nauplii could not eat some species of large diatoms which were eaten by adults. Mullin and Brooks (1970a) fed unialgal cultures of *Ditylum brightwellii* (a large diatom) and *Thalassiosira fluviatilis* (a small diatom) to nauplii of *R. nasutus* and *Calanus helgolandicus*. *Calanus* nauplii were unable to eat the large diatom, but grew well when eating the small one. The reverse was true for *Rhincalanus* nauplii, which are larger than those of *Calanus*. Apparently *Rhincalanus* nauplii are large enough to capture and ingest the large diatom, but their filtering appendages are too coarse to collect the small diatom. The success of naupliar feeding is apparently important to the ultimate success of a copepod. Mullin and Brooks (1970b) found that the body weights of late-stage copepodites and growth efficiencies were functions of food concentrations encountered by copepods as nauplii.

Nauplii of *Calanus helgolandicus* have been cultured on diets of several dinoflagellate and chain-forming diatom species (Paffenhöfer 1970, 1971, 1976a). Ingestion rates increased with both increasing food concentration and particle size. Unialgal diets of chain-forming diatoms also have been used to rear nauplii of

*Pseudocalanus elongatus* and *Temora longicornis* (Paffenhöfer and Harris 1976; Harris and Paffenhöfer 1976a, b).

Allan et al. (1977) examined the feeding of naupliar stages III-VI of three estuarine copepods (*Eurytemora affinis*, *Acartia tonsa*, and *A. clausi*) on natural particulates. In a few cases there was evidence of size-selective feeding, but most feeding was unselective.

Paffenhöfer and Knowles (1978) offered nauplii of *Eucalanus pileatus*, *Temora stylifera*, and *T. turbinata* mixtures of two chain-forming and one large solitary (*Rhizosolenia*) diatom species. *Eucalanus pileatus* nauplii larger than stage IV, copepodites, and adults ingested similar percentages of the three phytoplankters. However, the nauplii of the two *Temora* species ingested only one of the chain-formers (*Skeletonema costatum*), and only nauplii larger than stage IV ingested the other (*Leptocylindrus danicus*). Ingestion of *Rhizosolenia* by *Temora* subadults did not commence until copepodite stage II. Paffenhöfer and Knowles (1978) concluded that the size range of cells eaten by *Temora* nauplii was 4-20  $\mu\text{m}$  diameter, whereas that for *Eucalanus* nauplii was 4.5 to > 100  $\mu\text{m}$ .

Fernandez (1979a, b) fed *Calanus pacificus* nauplii on mixtures of culture! phytoplankton and artificial foods such as plastic beads, pollen grains, or detritus from senescent algal cultures. Phytoplankton were selected over artificial foods, but phytoplankton cells > 45  $\mu\text{m}$  or < 11  $\mu\text{m}$  in longest dimension were not eaten well, due to the inability of nauplii to manipulate larger cells or to retain smaller ones. Fernandez found that ingestion rates were dependent upon algal size. Further, dinoflagellates, regardless of size, were ingested at lower rates than diatoms.

In conclusion, most copepod nauplii appear to eat primarily phytoplankton, the size and type of which varies with copepod species and stage of nauplius. Thus far, however, the feeding habits of nauplii of only about a dozen copepod species have been examined. Considering the high numbers of nauplii usually present in the sea, the current lack of information on the dynamics of feeding by copepod nauplii precludes realistic understanding of pelagic ecosystem dynamics.

## TINTINNIDS

Tintinnids are ciliate protozoans which appear to be primarily herbivorous. Lebour (1922) found that *Cittarocyclis serrata* ate eight species of dinoflagellates, one species of diatom, and two species of tintinnids. Since the tintinnids and dinoflagellates were present only in summer, and dinoflagellates were the main food items of the tintinnids, Lebour classified *C. serrata* as a "peridiniian feeder."

Stoecker et al. (1981) also found dinoflagellates to be important in the diet of *Favella ehrenbergii*. Successful culture of this tintinnid required dinoflagellate food. Further, in selective feeding experiments, dinoflagellates (11 species) were always consumed, but there was little if any grazing of nondinoflagellates (12 species of diatoms, microflagellates, and chlorophytes). Selection of dinoflagellates was not on the basis of size alone. One dinoflagellate, *Amphidinium carterae* was not eaten; this species has been suggested to produce ectocrines which repel grazers. Blackburn (1974), however, found that *A. carterae*, as well as many nondinoflagellates were eaten by various tintinnid species (see table 2 of Rassoulzadegan and Etienne 1981 for a summary of Blackburn's unpublished work). Stoecker et al. (1981) concluded that *F. ehrenbergii* is a specialized dinoflagellate predator which consumes few, if any, of the nondinoflagellates tested.

While the conclusion of Stoecker et al. (1981) may apply to *F. ehrenbergii*, it clearly does not apply for some other tintinnids. Gold (1968, 1969a, b, 1970, 1971, 1973) has cultured five other species of tintinnids on diets of microflagellates. Only one of the five tintinnids required dinoflagellate food for successful culture.

Heinbokel (1978a) also found that five additional tintinnid species ingested three species of microflagellates and one species of coccolithophorid, either singly or in combination. For the three tintinnid species studied most extensively, one showed increasing ingestion rates with increasing food concentration, with no plateau. The other two species exhibited increasing ingestion rates with increasing food up to a saturation plateau. Since these tintinnids ingested 10-20% of their body weight per day, converted this ration to tintinnid biomass with > 50% efficiency, and exhibited doubling times of 12-24 h, Heinbokel (1978a) and Heinbokel and Beers (1979) concluded that tintinnids are capable of substantial grazing impact on nanoplankton. Capriulo and Carpenter (1983) similarly concluded that the tintinnid populations of Long Island Sound were responsible for ingesting 27% of the annual primary productivity in the estuary. This community ingestion was equivalent to that calculated for the Long Island Sound copepod population.

Rassoulzadegan and Etienne (1981) examined the feeding of *Stenosemella ventricosa* on natural particulates, and reported this tintinnid to feed on nanoplankton-sized particles (< 27  $\mu\text{m}$  in diameter) primarily in the 3-12  $\mu\text{m}$  size range. Ingestion rate was a linear function of food concentration, with no saturation over the range of food concentrations examined. The tintinnid ingested about 66% of its body weight per day. After feeding for a time on a certain size range of particles, it adjusted its grazing pressure to other size categories which had not been previously grazed.

Thus it appears that various species of tintinnids feed mainly on nanoplankton-sized flagellates and/or dinoflagellates. Part of the lack of agreement on tintinnid diets probably is due to the large variation in size of lorica oral diameters of various tintinnid species. For instance, the oral lorica diameter of *Eutintinnus pectinis* is 20  $\mu\text{m}$  (Turner and Anderson 1983), whereas that of *Favella panamensis* is > 100  $\mu\text{m}$  (Turner unpubl. obs.). These differences are important since various tintinnid species have been shown to ingest particles only < 41-45% of their lorica oral diameter (Spittler 1973; Heinbokel 1978b). In addition, other phytoplankters such as the flagellate *Olisthodiscus luteus* appear to be unsuitable as food for some tintinnids for reasons related to toxicity rather than size (Verity and Stoecker 1982).

There has been abundant speculation that tintinnids are a major trophic link between the nanoplankton upon which they feed, and larger plankters such as copepods and larval fish which might prey upon tintinnids (Beers and Stewart 1967; Heinbokel and Beers 1979; Pomeroy 1974; Parsons and Takahashi 1973). Apparently the first synoptic demonstration of this is the observation of Turner and Anderson (1983) that *Eutintinnus pectinis* cells containing the microflagellate *Chroomonas amphioxea* were ingested by the copepod *Acartia hudsonica*.

## APPENDICULARIANS

Appendicularians are gelatinous tunicates which are ubiquitous throughout the ocean. They feed by a ciliary mucoid mechanism using an external mucus filter. A spherical mucus "house" expands around the animal, through which water is pumped by action of the animal's tail, and particles are trapped on incurrent filters. When the "house" becomes clogged, the animal discards it



and secretes a new one (Alldredge 1977; Alldredge and Madin 1982).

Appendicularians feed primarily on nanoplankton-sized particles (Alldredge 1977, 1981). They can retain particles as small as 0.1  $\mu\text{m}$  in diameter, and particles < 2  $\mu\text{m}$  are the largest component of their gut contents (Alldredge and Madin 1982). Paffenhöfer (1973, 1976c) has cultured *Oikopleura dioica* and *Frittilaria borealis* for multiple generations on diets of the microflagellates *Isochrysis galbana* and *Monochrysis lutheri*, and the small diatom *Thalassiosira pseudonana*. *Oikopleura dioica* also exhibits substantial grazing on bacterioplankton (King 1982; King et al. 1980).

Alldredge (1981) measured in situ filtration rates of two appendicularian species and found that, compared with filtration rates of other zooplankters, those of appendicularians were high. Multiplying these rates by the number of animals present, Alldredge found that appendicularians could filter clear up to 38% of each cubic meter per day, a rate which exceeded particle replacement by phytoplankton growth.

Appendicularian growth rates are high, and populations of these animals can "explode" in response to bacterioplankton and nanophytoplankton blooms (King 1982; Paffenhöfer 1976c; Alldredge and Madin 1982). Since appendicularians feed on nanoplankton-sized particles, and are directly consumed by larval fish (Shelbourne 1953, 1957, 1962; Uotani et al. 1981; Wyatt 1974), they provide a major trophic link between the lower and upper parts of the pelagic food chain.

## MARINE CLADOCERANS

Although most cladoceran species live in freshwater, three genera (*Podon*, *Evadne*, and *Penilia*) comprising seven species inhabit the sea. Due to parthenogenic reproduction, cladoceran populations can "explode" under favorable conditions and may become numerically dominant zooplankters at a given place and time (Della Croce and Venugopal 1973; Gieskes 1971; Onbe 1977).

The existing literature on the feeding habits of marine cladocerans is sparse and somewhat contradictory. For instance, Conover (1978a: 272-273) stated that "*Evadne* and *Podon* seem to feed largely on discrete particles and perhaps detritus... but no experimental observations have been made." Examination of feeding appendages prompted Nival and Ravera (1979) to suggest that *Evadne spinifera* possesses the ability to catch and hold animal prey or large algal cells, although no confirming observations were reported. Lebour (1922) found green remains of *Phaeocystis* in the guts of *Evadne normanni* and soft brown remains with no apparent structure in the guts of *Podon intermedius*. Bainbridge (1958) also reported unrecognizable remains in the guts of *E. normanni*. Pavlova (1967) found no phytoplankton remains in the guts of *E. spinifera* and *E. tergestina*. Since some of the particles were "very much like chitin," Pavlova concluded that *Evadne* eats zooplankton and detritus. White (1980) observed that the gut contents of *E. normanni* collected during a bloom of the red tide dinoflagellate *Gonyaulax excavata* contained "yellow-brown material consisting of chromatophore-like bodies" which he assumed to be remains of *G. excavata*. The cladocerans also contained intact cells of the large (up to 300  $\mu\text{m}$  diameter) diatom *Coscinodiscus asteromphalus*.

The only other marine cladoceran that has received any study is *Penilia avirostris*, which Pavlova (1959) stated is an indiscriminant filter feeder utilizing only particles < 8  $\mu\text{m}$  in diameter. Gore (1980) reported, however, that this species ingested glass beads of up to 50  $\mu\text{m}$  in diameter but preferred beads < 20  $\mu\text{m}$ . Several

Soviet investigators have stated that *P. avirostris* feeds on small phytoplankton and detritus, but primarily on bacteria (Pavlova 1959; Pavlova and Sorokin 1970 — cited in Conover 1978a; Sorokin et al. 1970; Pavlova et al. 1973; Sorokin 1973, 1981; Petipa et al. 1973). Nonetheless, since copepods as large as *Rhincalanus cornutus* (body length = 2.7 mm for males, 3.6 mm for females), *Eucalanus attenuatus* (body length = 3 mm for males, 4-5 mm for females), and *Clausocalanus mastigophorus* (body length = 1.0-1.5 mm for males, 1.2-1.8 mm for females) (lengths from Rose 1933 and Frost and Fleminger 1968) also have been stated to ingest 10-75% of their body carbon per day as bacteria (Sorokin 1981), the claims that cladocerans eat primarily bacteria appear deserving of further investigation.

In summary, there is disagreement about, or extreme variability in, the nature and sizes of food eaten by marine cladocerans. The paucity of knowledge on the feeding habits of these animals is reflected by the fact that in his 278-page review of feeding by marine animals, Conover (1978a) devoted nine sentences (p. 272, 273, 293, 294) to summarizing existing knowledge on marine cladoceran feeding.

## BARNACLE NAUPLII

Barnacle nauplii appear primarily herbivorous. Lebour (1922) found that guts of several species contained remains of green flagellates, diatoms, and *Phaeocystis*. Moyses (1963) compared the suitability as food of unialgal cultures of 17 species of microflagellates, dinoflagellates, and diatoms for nauplii of 5 barnacle species. The palatability of various phytoplankters to nauplii of different barnacles varied. Two dinoflagellates, *Amphidinium* and *Prymnesium*, were unsuitable food for all nauplii, and *Chlorella* and *Dunaliella*, while eaten, did not allow nauplii to develop completely. *Balanus* nauplii could be reared on diatoms but not on flagellates; for *Chthamalus* nauplii the reverse was true. *Eliminius* nauplii grew well on a wide range of phytoplankters. Nauplii of the oceanic barnacle *Lepas* grew well on diets of flagellates but not on diets of diatoms. Moyses (1963) suggested that growth was better because flagellates are usually more abundant than diatoms in oceanic waters. Conversely, nauplii of the arctic/boreal barnacle *Verruca* grew best on diatoms, which usually dominate the phytoplankton in arctic/boreal waters. Moyses suggested that the unsuitability of chain-forming diatoms as food for nauplii of some species was due to their clogging the finely setulated filtering appendages of the nauplii. Clogging did not occur when these species fed upon small flagellates. Moyses concluded that nauplii of different barnacle species have different diet requirements.

Other species of barnacles have been reared successfully through naupliar stages on unialgal or mixed diets of diatoms and microflagellates (Wisely 1960; Moyses 1960; Barnes and Costlow 1961; Tighe-Ford et al. 1970; Karande 1974a, b). Further, Costlow and Bookout (1957, 1958) reared two other barnacle species on diets of *Chlamydomonas*, but found that completion of development required addition of starfish (*Arbacia*) eggs in the later stages of development. Aside from the observations of Costlow and Bookout, however, it appears that most barnacle nauplii are primarily herbivorous although the types of phytoplankton eaten vary with barnacle species.

## GASTROPOD LARVAE

Most gastropod larvae examined feed on phytoplankton. Gut contents contained remains of a variety of diatoms (Lebour 1922),

and Thompson (1959) fed the diatom *Phaeodactylum tricornutum* to larvae of numerous gastropod species.

Fretter and Montgomery (1968) examined the feeding of veligers of 19 gastropod species on cultures of 3 dinoflagellate, 7 microflagellate, 4 nanochlorophyte, and 4 diatom species. Some phytoplankters clearly were unsuitable food. The flagellate *Olisthodiscus* was either undigested or, for some veligers, was toxic. *Monochrysis* was also lethal to veligers of four species. However, most of the phytoplankters were readily ingested, except for large (> 30  $\mu\text{m}$  cell diameter) or chain-forming species, which clogged the preoral cilia of some veligers.

Mapstone (1970) fed unialgal cultures of the dinoflagellate *Exuviaella baltica* and two microflagellates to veligers of *Nassarius reticulatus* and *Crepidula fornicata*. Based on activity of veligers while feeding, the microflagellates were good food for *N. reticulatus* veligers but *E. baltica* was not. The reverse was true for *C. fornicata* veligers. Pilkington and Fretter (1970), using the same phytoplankters as food, examined growth of veligers of the same species and reached the same conclusions. Of five additional microflagellate species, four were poor foods, and of these two were toxic. A diatom was also poor food because the frustules were too large for convenient ingestion, and they appeared to stimulate gut pulsations, which Pilkington and Fretter considered indicative of irritation. Pilkington and Fretter also found that veligers of both gastropods ingested several strains of bacteria.

The limited available information suggests that gastropod larvae are primarily phytoplankton, and possible bacterioplankton, feeders.

## LIMACINA

*Limacina* is a genus of pteropod (holoplanktonic molluscs). Although gymnosomatous or nonshelled pteropods appear to prey principally, or exclusively, upon thecosomatous or shell-bearing pteropods (Lalli 1970, 1972; Conover and Lalli 1972, 1974), thecosomes are ciliary-mucoid filter feeders (Yonge 1926; Morton 1954; Lalli 1970; Gilmer 1972, 1974; Silver and Bruland 1981). The guts of *Limacina retroversa*, a thecosome, contained remains of diatoms (Lebour 1922) and Morton (1954) assumed that it ate dinoflagellates and nanoplankton as well. Paranjape (1968) found that *L. helicina* guts contained some remains of chain-forming diatoms, but that remains of dinoflagellates and tintinnids were most abundant.

These limited observations suggest that species of *Limacina* are primarily herbivorous filter feeders.

## DISCUSSION

Several points should emerge from this review: 1) Most zooplankters, particularly copepods, appear to be omnivorous feeders; 2) we still have too little information on the exact mechanisms by which many zooplankters capture and select (or even if some select) various types of food; and 3) we know next to nothing about the feeding habits in nature of some very abundant zooplankters.

Since the time of Lebour (1922) it has been known that most copepods are omnivorous, ingesting plant, animal, and detrital foods. In the absence of detailed examinations of gut contents and quantitative comparisons of ingestion of various types of food, attempts to use mouthpart structures to classify copepods as herbivores or carnivores (Itoh 1970; Arashkevich 1969) appear unwarranted. Indeed, some copepods thought to be primarily carnivorous (pontellids) have been shown to ingest a variety of

phytoplankters (Turner 1978; Conley 1983) and some "typical" herbivores such as *Calanus* have been shown to feed as carnivores (Corner et al. 1974, 1976; Landry 1980, 1981). Missing for most species are not only qualitative descriptions of food items ingested in nature, but also quantitative comparisons using natural food of the relative importance of herbivorous and carnivorous feeding. The studies of Paffenhöfer and Knowles (1980), Landry (1981), and Conley (1983) represent steps in that direction. Observations by Landry (1981) that *Calanus* can switch from eating phytoplankton to eating zooplankton, and vice versa, suggest that copepod feeding preferences are quite plastic. If this pattern is generally applicable, the idea that alteration of phytoplankton species assemblages may result in adverse trophodynamic alteration of zooplankton and ichthyoplankton assemblages appears simplistic. The true pattern may be that most zooplankters, including larval fish, eat their "favorite" food if it is present and abundant, and if not, they make do by eating something else.

Many classic concepts of the manner by which copepods gather food have recently been shown to require revision. The "textbook" description of copepods using bristled appendages such as the second maxillae as open rakes to strain particles from water by filtration (Esterly 1916; Cannon 1928; Lowndes 1935; Marshall and Orr 1955c; Gauld 1966; Boyd 1976; Nival and Nival 1976; Frost 1977) has been altered by cinematographic studies which show that these appendages behave as solid paddles, capturing whole parcels of water containing food particles which are brought to the mouth with hardly touching setae or setules (Alcaraz et al. 1980; Koehl and Strickler 1981; Paffenhöfer et al. 1982; Strickler 1982). There also is increasing evidence that "selection" of various types of food, or even induction of feeding, has a chemosensory component (Poulet and Marsot 1978, 1980; Friedman and Strickler 1975; Cox and Willason 1981). Although food particle size may broadly dictate what types of food items can be physically handled by the feeding apparatus of a zooplankter, and although certain sizes of food items appear to be more efficiently ingested than others, it is becoming clear that selective feeding, if and when it occurs, is not solely on the basis of particle size. Indeed, recent experimental (Harris 1982; Huntley 1981) and gut content (Hayward 1980) studies have revealed that different sized copepods compete for the same broad size array of food items. In view of these observations, and those of Harbison and McAlister (1980) on artifacts associated with the use of electronic particle counters to study selective feeding by zooplankters upon natural particulate assemblages, it may be that we need to "unlearn" some of what we presently "know" of zooplankton feeding patterns.

The largest problem with the present state of knowledge of zooplankton feeding is that we have very little information on the feeding habits in nature of some ubiquitous taxa that are usually the most abundant. Particularly, these include cyclopoid copepods, nauplii of almost all types of copepods, and tintinnids and other ciliates. The same applies to other taxa such as marine cladocerans, appendicularians, thaliaceans, and various types of meroplankters which, although less ubiquitously abundant, exhibit sporadic and localized population increases. Limited information suggests that the trophodynamic impact of such population pulses can be substantial (Seki 1973; Wiebe et al. 1979).

In conclusion, I return to the thesis presented in the introduction, namely that understanding of fishery dynamics requires understanding of the dynamics of food webs supporting larval fish. Sandwiched between a need to understand responses of planktonic primary producers to climatic, oceanographic, and

anthropogenic-induced variability, and a need to understand trophic interactions between larval fish and their prey, is a critical need to understand dynamics and patterns of zooplankton feeding.

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## LITERATURE CITED

- ADAMS, J. A., and J. H. STEELE.  
1966. Shipboard experiments on the feeding of *Calanus finmarchicus* (Gunnerus). In H. Barnes (editor), Some contemporary studies in marine science, p. 19-35. Allen and Unwin Ltd., Lond.
- ALCARAZ, M., G.-A. PAFFENHÖFER, and J. R. STRICKLER.  
1980. Catching the algae: A first account of visual observations on filter-feeding calanoids. In W. C. Kerfoot (editor), Evolution and ecology of zooplankton communities, p. 241-248. University Press of New England, Hanover, N.H.
- ALLAN, J. D., S. RICHMAN, D. R. HEINLE, and R. HUFF.  
1977. Grazing in juvenile stages of some estuarine calanoid copepods. Mar. Biol. (Berl.) 43:317-331.
- ALLDREDGE, A. L.  
1972. Abandoned larvacean houses: A unique food source in the pelagic environment. Science (Wash., D.C.) 177:885-887.  
1977. House morphology and mechanisms of feeding in the Oikopleuridae (Tunicata, Appendicularia). J. Zool. (Lond.) 181:175-188.  
1981. The impact of appendicularian grazing on natural food concentrations in situ. Limnol. Oceanogr. 26:247-257.
- ALLDREDGE, A. L., and L. P. MADIN  
1982. Pelagic tunicates: Unique herbivores in the marine plankton. Bio-Science 32:655-663.
- ANRAKU, M.  
1964a. Influence of the Cape Cod Canal on the hydrography and on the copepods in Buzzards Bay and Cape Cod Bay, Massachusetts. II. Respiration and feeding. Limnol. Oceanogr. 9:195-206.  
1964b. Some technical problems encountered in quantitative studies of grazing and predation by marine planktonic copepods. J. Oceanogr. Soc. Jpn. 20:221-231.
- ANRAKU, M., and M. OMORI.  
1963. Preliminary survey of the relationship between the feeding habit and the structure of the mouth-parts of marine copepods. Limnol. Oceanogr. 8:116-126.
- ARASHKEVICH, Ye. G.  
1969. The food and feeding of copepods in the northwestern Pacific. Oceanology 9:695-709.
- ARTHUR, D. K.  
1976. Food and feeding of larvae of three fishes occurring in the California Current, *Sardinops sagax*, *Engraulis mordax*, and *Trachurus symmetricus*. Fish. Bull., U.S. 74:517-530.
- BAINBRIDGE, V.  
1958. Some observations on *Evadne nordmanni* Lovén. J. Mar. Biol. Assoc. U.K. 37:349-370.  
1965. A preliminary study of *Sebastes* larvae in relation to the planktonic environment of the Irminger Sea. Spec. Publ. Int. Comm. Northwest Atl. Fish. 6:303-308.
- BAINBRIDGE, V., and D. C. T. FORSYTH.  
1971. The feeding of herring larvae in the Clyde. Rapp. P.-V. Réun. Cons. Int. Explor. Mer 160:104-113.
- BARNES, H., and J. D. COSTLOW, Jr.  
1961. The larval stages of *Balanus balanus* (L.) Da Costa. J. Mar. Biol. Assoc. U.K. 41:59-68.
- BARTRAM, W. C.  
1981. Experimental development of a model for the feeding of neritic copepods on phytoplankton. J. Plankton Res. 3:25-51.
- BEERS, J. R., and G. L. STEWART.  
1967. Micro-zooplankton in the euphotic zone at five locations across the California Current. J. Fish. Res. Board Can. 24:2053-2068.
- BERNARD, M.  
1963a. Adaptation de quelques copépodes pélagiques Méditerranéens à différents milieux de survie en aquarium. Rapp. P.-V. Réun. Comm. Int. Explor. Sci. Mer Méditerran. 16:165-176.  
1963b. Observations sur la biologie en aquarium de *Euterpina acutifrons*, copépode pélagique. Rapp. P.-V. Réun. Comm. Int. Explor. Sci. Mer Méditerran. 17:545.
- BERNER, A.  
1962. Feeding and respiration in the copepod *Temora longicornis* (Müller). J. Mar. Biol. Assoc. U.K. 42:625-640.
- BJØRKE, H.  
1971. The food of herring larvae of Norwegian spring spawners. Rapp. P.-V. Réun. Cons. Int. Explor. Mer 160:101-103.  
1978. Food and feeding of young herring larvae of Norwegian spring spawners. Fiskeridir. Skr. Ser. Havunders. 16:405-422.
- BJORNBERG, T. K. S.  
1965. Observations on the development and the biology of the Miracidae Dana (Copepoda:Crustacea). Bull. Mar. Sci. 15:512-520.
- BLACKBOURN, D. J.  
1974. The feeding biology of tintinnid protozoa and some other inshore microzooplankton. Ph.D. Thesis, Univ. British Columbia, Vancouver.
- BLAXTER, J. H. S.  
1965. The feeding of herring larvae and their ecology in relation to feeding. Calif. Coop. Oceanic Fish. Invest. Rep. 10:79-88.
- BLAXTER, J. H. S. (editor).  
1974. The early life history of fish. Springer-Verlag, N.Y., 765 p.
- BOWERS, A. B., and D. I. WILLIAMSON.  
1951. Food of larval and early post-larval stages of autumn-spawned herring in Manx waters. Annu. Rep. Mar. Biol. Stn. Port Erin 63:17-26.
- BOYD, C. M.  
1976. Selection of particle sizes by filter-feeding copepods: A plea for reason. Limnol. Oceanogr. 21:175-180.
- BOYD, C. M., S. L. SMITH, and T. J. COWLES.  
1980. Grazing patterns of copepods in the upwelling system off Peru. Limnol. Oceanogr. 25:583-596.
- BRADFORD, J. M.  
1976. Partial revision of the *Acartia* subgenus *Acartiura* (Copepoda: Calanoida: Acartiidae). N.Z. J. Mar. Freshw. Res. 10:159-202.
- BROWN, T. J., and J. R. SIBERT.  
1977. Food of some benthic harpacticoid copepods. J. Fish. Res. Board Can. 34:1028-1031.
- BUTLER, E. I., E. D. S. CORNER, and S. M. MARSHALL.  
1969. On the nutrition and metabolism of zooplankton. VI. Feeding efficiency of *Calanus* in terms of nitrogen and phosphorus. J. Mar. Biol. Assoc. U.K. 49:977-1001.  
1970. On the nutrition and metabolism of zooplankton. VII. Seasonal survey of nitrogen and phosphorus excretion by *Calanus* in the Clyde Sea-area. J. Mar. Biol. Assoc. U.K. 50:525-560.
- CAHOON, L. B.  
1981. Reproductive response of *Acartia tonsa* to variations in food ration and quality. Deep-Sea Res. 28:1215-1221.
- CANNON, H. G.  
1928. On the feeding mechanism of the copepods, *Calanus finmarchicus* and *Diaptomus gracilis*. Br. J. Exp. Biol. 6:131-144.
- CAPRIULO, G. M., and E. J. CARPENTER.  
1983. Abundance, species composition and feeding impact of tintinnid micro-zooplankton in central Long Island Sound. Mar. Ecol. Prog. Ser. 10:277-288.
- CHECKLEY, D. M., Jr.  
1980. The egg production of a marine planktonic copepod in relation to its food supply: Laboratory studies. Limnol. Oceanogr. 25:430-446.
- CIECHOMSKI, J. D. de.  
1967. Investigations of food and feeding habits of larvae and juveniles of the Argentine anchovy *Engraulis anchoita*. Calif. Coop. Oceanic Fish. Invest. Rep. 11:72-81.
- CLARKE, G. L., and D. D. BONNET.  
1939. The influence of temperature on the survival, growth and respiration of *Calanus finmarchicus*. Biol. Bull. (Woods Hole) 76:371-383.
- CLARKE, G. L., and S. S. GELLIS.  
1935. The nutrition of copepods in relation to the food-cycle of the sea.

- COLLETTE, B. B.  
1978. Adaptations and systematics of the mackerels and tunas. In G. D. Sharp and A. E. Dizon (editors), *The physiological ecology of tunas*, p. 7-88. Acad. Press, N.Y.
- CONLEY, W. J.  
1983. A comparison of herbivory and carnivory for two coastal marine copepods. M.S. Thesis, Southeastern Massachusetts University, North Dartmouth, 115 p.
- CONOVER, R. J.  
1956. Oceanography of Long Island Sound, 1952-1954. VI. Biology of *Acartia clausi* and *A. tonsa*. Bull. Bingham Oceanogr. Collect. Yale Univ. 15:156-233.  
1959. Regional and seasonal variation in the respiratory rate of marine copepods. Limnol. Oceanogr. 4:259-268.  
1960. The feeding behavior and respiration of some marine planktonic Crustacea. Biol. Bull. (Woods Hole) 119:399-415.  
1966a. Feeding on large particles by *Calanus hyperboreus* (Krøyer). In H. Barnes (editor), *Some contemporary studies in marine science*, p. 187-194. Allen and Unwin Ltd., Lond.  
1966b. Assimilation of organic matter by zooplankton. Limnol. Oceanogr. 11:338-345.  
1966c. Factors affecting the assimilation of organic matter by zooplankton and the question of superfluous feeding. Limnol. Oceanogr. 11:346-354.  
1971. Some relations between zooplankton and Bunker C oil in Chedabucto Bay following the wreck of the tanker *Arrow*. J. Fish. Res. Board Can. 28:1327-1330.  
1978a. Transformation of organic matter. In O. Kinne (editor), *Marine ecology*, Vol. IV, Dynamics, p. 221-499. John Wiley & Sons, N.Y.  
1978b. Feeding interactions in the pelagic zone. Rapp. P.-V. Réun. Cons. Int. Explor. Mer 173:66-76.
- CONOVER, R. J., and C. M. LALLI.  
1972. Feeding and growth in *Clione limacina* (Phipps), a pteropod mollusc. J. Exp. Mar. Biol. Ecol. 9:279-302.  
1974. Feeding and growth in *Clione limacina* (Phipps), a pteropod mollusc. II. Assimilation, metabolism, and growth efficiency. J. Exp. Mar. Biol. Ecol. 16:131-154.
- CONWAY, D. V. P.  
1980. The food of larval blue whiting, *Micromesistius poutassou* (Risso), in the Rockall area. J. Fish Biol. 16:709-723.
- CORKETT, C. J.  
1967. Technique for rearing marine calanoid copepods in laboratory conditions. Nature (Lond.) 216:58-59.  
1970. Techniques for breeding and rearing marine calanoid copepods. Helgol. wiss. Meeresunters. 20:318-324.
- CORKETT, C. J., and I. A. McLAREN.  
1978. The biology of *Pseudocalanus*. Adv. Mar. Biol. 15:1-231.
- CORKETT, C. J., and E. J. ZILLIOUX.  
1975. Studies on the effect of temperature on the egg laying of three species of calanoid copepods in the laboratory (*Acartia tonsa*, *Temora longicornis* and *Pseudocalanus elongatus*). Bull. Plankton Soc. Jpn. 21:77-85.
- CORNER, E. D. S.  
1961. On the nutrition and metabolism of zooplankton, I. Preliminary observations on the feeding of the marine copepod, *Calanus helgolandicus* (Claus). J. Mar. Biol. Assoc. U.K. 41:5-16.
- CORNER, E. D. S., C. B. COWEY, and S. M. MARSHALL.  
1967. On the nutrition and metabolism of zooplankton. V. Feeding efficiency of *Calanus finmarchicus*. J. Mar. Biol. Assoc. U.K. 47:259-270.
- CORNER, E. D. S., R. N. HEAD, and C. C. KILVINGTON.  
1972. On the nutrition and metabolism of zooplankton. VIII. The grazing of *Biddulphia* cells by *Calanus helgolandicus*. J. Mar. Biol. Assoc. U.K. 52:847-861.
- CORNER, E. D. S., R. N. HEAD, C. C. KILVINGTON, and S. M. MARSHALL.  
1974. On the nutrition and metabolism of zooplankton. IX. Studies relating to the nutrition of overwintering *Calanus*. J. Mar. Biol. Assoc. U.K. 54:319-331.
- CORNER, E. D. S., R. N. HEAD, C. C. KILVINGTON, and L. PENNYCUICK.  
1976. On the nutrition and metabolism of zooplankton. X. Quantitative aspects of *Calanus helgolandicus* feeding as a carnivore. J. Mar. Biol. Assoc. U.K. 56:345-358.
- COSTLOW, J.D., Jr., and C. G. BOOKOUT.  
1957. Larval development of *Balanus eburneus* in the laboratory. Biol. Bull. (Woods Hole) 112:313-324.  
1958. Larval development of *Balanus amphitrite* var. *denticulata* Broch reared in the laboratory. Biol. Bull. (Woods Hole) 114:284-295.
- COVILL, R. W.  
1959. Food and feeding habits of larvae and postlarvae of *Ammodytes americanus*, 1952-1955. Bull. Bingham Oceanogr. Collect. Yale Univ. 17:125-146.
- COWEY, C. B., and E. D. S. CORNER.  
1963. On the nutrition and metabolism of zooplankton. II. The relationship between the marine copepod *Calanus helgolandicus* and particulate material in Plymouth sea water, in terms of amino acid composition. J. Mar. Biol. Assoc. U.K. 43:495-511.
- COWLES, T. J.  
1979. The feeding response of copepods from the Peru upwelling system: Food size selection. J. Mar. Res. 37:601-622.
- COWLES, T. J., and J. R. STRICKLER.  
1983. Characterization of feeding activity patterns in the planktonic copepod *Centropages typicus* Kroyer under various food conditions. Limnol. Oceanogr. 28:106-115.
- COX, J. L., and S. W. WILLASON.  
1981. Laminarinase induction in *Calanus pacificus*. Mar. Biol. Lett. 2:307-311.
- CUSHING, D. H.  
1958. The effect of grazing in reducing the primary production: A review. Rapp. P.-V. Réun. Cons. Int. Explor. Mer 144:149-154.  
1964. The work of grazing in the sea. In D. J. Crisp (editor), *Grazing in terrestrial and marine environments*, p. 207-225. Blackwell Sci. Publ., Oxford.
- CUSHING, D. H., and T. VUCETIC.  
1963. Studies on a *Calanus* patch. III. The quantity of food eaten by *Calanus finmarchicus*. J. Mar. Biol. Assoc. U.K. 43:349-371.
- DAGG, M.  
1977. Some effects of patchy food environments on copepods. Limnol. Oceanogr. 22:99-107.  
1978. Estimated, *in situ*, rates of egg production for the copepod *Centropages typicus* (Krøyer) in the New York Bight. J. Exp. Mar. Biol. Ecol. 34:183-196.
- DAGG, M., T. COWLES, T. WHITLEDGE, S. SMITH, S. HOWE, and D. JUDKINS.  
1980. Grazing and excretion by zooplankton in the Peru upwelling system during April 1977. Deep-Sea Res. 27:43-59.
- DAGG, M. J., and D. W. GRILL.  
1980. Natural feeding rates of *Centropages typicus* females in the New York Bight. Limnol. Oceanogr. 25:597-609.
- DAGG, M. J., and J. T. TURNER.  
1982. The impact of copepod grazing on the phytoplankton of Georges Bank and the New York Bight. Can. J. Fish. Aquat. Sci. 39:979-990.
- DAGG, M. J., J. VIDAL, T. E. WHITLEDGE, R. L. IVERSON, and J. J. GOERING.  
1982. The feeding, respiration, and excretion of zooplankton in the Bering Sea during a spring bloom. Deep-Sea Res. 29:45-63.
- DAKIN, W. J.  
1908. Notes on the alimentary canal and food of the Copepoda. Int. Rev. Gesamten Hydrobiol. Hydrogr. 1:772-782.
- DAVIS, C. C.  
1977. *Sagitta* as food for *Acartia*. Astarte 10:1-3.
- DEASON, E. E.  
1980a. Potential effect of phytoplankton colony breakage on the calculation of zooplankton filtration rates. Mar. Biol. (Berl.) 57:279-286.  
1980b. Grazing of *Acartia hudsonica* (A. clausi) on *Skeletonema costatum* in Narragansett Bay (USA): Influence of food concentration and temperature. Mar. Biol. (Berl.) 60:101-113.
- DELLA CROCE, N., and P. VENUGOPAL.  
1973. *Penilia avirostris* Dana in the Indian Ocean (Cladocera). Int. Rev. Gesamten Hydrobiol. 58:713-721.
- DETWYLER, R., and E. D. HOUE.  
1970. Food selection by laboratory-reared larvae of the scaled sardine *Harengula pensacolatae* (Pisces, Clupeidae) and the bay anchovy *Anchoa mitchilli* (Pisces, Engraulidae). Mar. Biol. (Berl.) 7:214-222.
- DIGBY, P. S. B.  
1954. The biology of the marine planktonic copepods of Scoresby Sound, East Greenland. J. Anim. Ecol. 23:298-338.
- DONAGHAY, P. L., and L. F. SMALL.  
1979a. Long-term food modification by *Acartia clausi*: A preliminary view. Mar. Biol. (Berl.) 52:129-136.  
1979b. Food selection capabilities of the estuarine copepod *Acartia clausi*. Mar. Biol. (Berl.) 52:137-146.
- ELLERTSEN, B., P. SOLEMDAL, S. SUNDBY, S. TILSETH, T. WESTGÅRD, and V. ØIESTAD.  
1981. Feeding and vertical distribution of cod larvae in relation to availability of prey organisms. Rapp. P.-V. Réun. Cons. Int. Explor. Mer 178:317-319.

- ESAIAS, W. E., and H. C. CURL, Jr.  
1972. Effect of dinoflagellate bioluminescence on copepod ingestion rates. *Limnol. Oceanogr.* 17:901-906.
- ESTERLY, C. O.  
1916. The feeding habits and food of pelagic copepods and the question of nutrition by organic substances in solution in the water. *Univ. Calif. Publ. Zool.* 16:171-184.
- FERNÁNDEZ, F.  
1979a. Nutrition studies in the nauplius larva of *Calanus pacificus* (Copepoda: Calanoida). *Mar. Biol. (Berl.)* 53:131-147.  
1979b. Particle selection in the nauplius of *Calanus pacificus*. *J. Plankton Res.* 1:313-328.
- FLEMINGER, A., and K. HULSEMANN.  
1973. Relationship of Indian Ocean epipelagic calanoids to the world oceans. In B. Zeitzschel (editor), *The biology of the Indian Ocean*, p. 339-347. Springer-Verlag, N.Y.
- FRETTER, V., and M.C. MONTGOMERY.  
1968. The treatment of food by prosobranch veligers. *J. Mar. Biol. Assoc. U.K.* 48:499-520.
- FRIEDMAN, M. M.  
1980. Comparative morphology and functional significance of copepod receptors and oral structures. In W. C. Kerfoot (editor), *Evolution and ecology of zooplankton communities*, p. 185-197. University Press of New England, Hanover, N.H.
- FRIEDMAN, M. M., and J. R. STRICKLER.  
1975. Chemoreceptors and feeding in calanoid copepods (Arthropoda: Crustacea). *Proc. Natl. Acad. Sci. U.S.A.* 72:4185-4188.
- FROST, B. W.  
1972. Effects of size and concentration of food particles on the feeding behavior of the marine planktonic copepod *Calanus pacificus*. *Limnol. Oceanogr.* 17:805-815.  
1975. A threshold feeding behavior in *Calanus pacificus*. *Limnol. Oceanogr.* 20:263-266.  
1977. Feeding behavior of *Calanus pacificus* in mixtures of food particles. *Limnol. Oceanogr.* 22:472-491.  
1980. The inadequacy of body size as an indicator of niches in the zooplankton. In W. C. Kerfoot (editor), *Evolution and ecology of zooplankton communities*, p. 742-753. University Press of New England, Hanover, N.H.
- FROST, B. W., and A. FLEMINGER.  
1968. A revision of the genus *Clausocalanus* (Copepoda: Calanoida) with remarks on distributional patterns in diagnostic characters. *Bull. Scripps Inst. Oceanogr., Univ. Calif.* 12:1-235.
- FROST, B. W., M. R. LANDRY, and R. P. HASSETT.  
1983. Feeding behavior of large calanoid copepods *Neocalanus cristatus* and *N. plumchrus* from the subarctic Pacific Ocean. *Deep-Sea Res.* 30:1-13.
- FULLER, J. L.  
1937. Feeding rate of *Calanus finmarchicus* in relation to environmental conditions. *Biol. Bull. (Woods Hole)* 72:233-246.
- FULLER, J. L., and G. L. CLARKE.  
1936. Further experiments on the feeding of *Calanus finmarchicus*. *Biol. Bull. (Woods Hole)* 70:308-320.
- GAMBLE, J. C.  
1978. Copepod grazing during a declining spring phytoplankton bloom in the northern North Sea. *Mar. Biol. (Berl.)* 49:303-315.
- GAMBLE, J. C., P. MacLACHLAN, N. T. NICOLL, and I. G. BAXTER.  
1981. Growth and feeding of Atlantic herring larvae reared in large plastic enclosures. *Rapp. P.-V. Réun. Couns. Int. Explor. Mer* 178:121-134.
- GAUDY, R.  
1974. Feeding four species of pelagic copepods under experimental conditions. *Mar. Biol. (Berl.)* 25:125-141.
- GAULD, D. T.  
1951. The grazing rate of planktonic copepods. *J. Mar. Biol. Assoc. U.K.* 29:695-706.  
1953. Diurnal variations in the grazing of planktonic copepods. *J. Mar. Biol. Assoc. U.K.* 31:461-474.  
1966. The swimming and feeding of planktonic copepods. In H. Barnes (editor), *Some contemporary studies in marine science*, p. 313-334. Allen and Unwin Ltd., Lond.
- GAULD, D. T., and J. E. G. RAYMONT.  
1953. The respiration of some planktonic copepods. II. The effect of temperature. *J. Mar. Biol. Assoc. U.K.* 31:447-460.
- GIBSON, V. R., and G. D. GRICE.  
1978. The developmental stages of a species of *Corycaeus* (Copepoda: Cyclopoida) from Saanich Inlet, British Columbia. *Can. J. Zool.* 56:66-74.
- GIENRIKH, A. K.  
1958. On the nutrition of marine copepods in the tropical region. *Dokl. Akad. Nauk SSSR* 119:229-232 (Engl. transl., *Am. Inst. Biol. Sci., Wash., D.C.*).
- GIESKES, W. W. C.  
1971. Ecology of the Cladocera of the North Atlantic and the North Sea, 1960-1967. *Neth. J. Sea Res.* 5:342-376.
- GIFFORD, D. J., R. N. BOHRER, and C. M. BOYD.  
1981. Spines on diatoms: Do copepods care? *Limnol. Oceanogr.* 26:1057-1061.
- GILMER, R. W.  
1972. Free-floating mucus webs: A novel feeding adaptation for the open ocean. *Science (Wash., D.C.)* 176:1239-1240.  
1974. Some aspects of feeding in thecosomatous pteropod molluscs. *J. Exp. Mar. Biol. Ecol.* 15:127-144.
- GOLD, K.  
1968. Some observations on the biology of *Tintinnopsis* sp. *J. Protozool.* 15:193-194.  
1969a. The preservation of tintinnids. *J. Protozool.* 16:126-128.  
1969b. Tintinnida: Feeding experiments and lorica development. *J. Protozool.* 16:507-509.  
1970. Cultivation of marine ciliates (Tintinnida) and heterotrophic flagellates. *Helgol. wiss. Meeresunters.* 20:264-271.  
1971. Growth characteristics of the mass-reared tintinnid *Tintinnopsis beroidea*. *Mar. Biol. (Berl.)* 8:105-108.  
1973. Methods for growing tintinnida in continuous culture. *Am. Zool.* 13:203-208.
- GOPHEN, M., and R. P. HARRIS.  
1981. Visual predation by a marine cyclopoid copepod, *Corycaeus anglicus*. *J. Mar. Biol. Assoc. U.K.* 61:391-399.
- GORE, M. A.  
1980. Feeding experiments on *Penilia avirostris* Dana (Cladocera: Crustacea). *J. Exp. Mar. Biol. Ecol.* 44:253-260.
- GOVONI, J. J., D. E. HOSS, and A. J. CHESTER.  
1983. Comparative feeding of three species of larval fishes in the northern Gulf of Mexico: *Brevoortia patronus*, *Leiostomus xanthurus*, and *Micropogonias undulatus*. *Mar. Ecol. Prog. Ser.* 13:189-199.
- GREVE, W., and T. R. PARSONS.  
1977. Photosynthesis and fish production: Hypothetical effects of climatic change and pollution. *Helgol. wiss. Meeresunters.* 30:666-672.
- HAQ, S. M.  
1965. The larval development of *Oithonina nana*. *J. Zool. (Lond.)* 146: 555-566.  
1972. Breeding of *Euterpina acutifrons*, a harpacticoid copepod, with special reference to dimorphic males. *Mar. Biol. (Berl.)* 15:221-235.
- HARBISON, G. R., and V. L. McALISTER.  
1980. Fact and artifact in copepod feeding experiments. *Limnol. Oceanogr.* 25:971-981.
- HARGRAVE, B. T., and G. H. GEEN.  
1970. Effects of copepod grazing on two natural phytoplankton populations. *J. Fish. Res. Board Can.* 27:1395-1403.
- HARRIS, R. P.  
1977. Some aspects of the biology of the harpacticoid copepod, *Scottolana canadensis* (Willey), maintained in laboratory culture. *Chesapeake Sci.* 18:245-252.  
1982. Comparison of the feeding behaviour of *Calanus* and *Pseudocalanus* in two experimentally manipulated enclosed ecosystems. *J. Mar. Biol. Assoc. U.K.* 62:71-91.
- HARRIS, R. P., and G.-A. PAFFENHÖFER.  
1976a. Feeding, growth and reproduction of the marine planktonic copepod *Temora longicornis* Müller. *J. Mar. Biol. Assoc. U.K.* 56:675-690.  
1976b. The effect of food concentration on cumulative ingestion and growth efficiency of two small marine planktonic copepods. *J. Mar. Biol. Assoc. U.K.* 56:875-888.
- HARVEY, H. W.  
1937. Note on selective feeding by *Calanus*. *J. Mar. Biol. Assoc. U.K.* 22: 97-100.
- HARVEY, H. W., L. H. N. COOPER, M. V. LEBOUR, and F. S. RUSSELL.  
1935. Plankton production and its control. *J. Mar. Biol. Assoc. U.K.* 20: 407-442.
- HAYWARD, T. L.  
1980. Spatial and temporal feeding patterns of copepods from the North Pacific central gyre. *Mar. Biol. (Berl.)* 58:295-309.
- HEBERT, R., and S. A. POULET.  
1980. Effect of modification of particle size of emulsions of Venezuelan crude oil on feeding, survival and growth of marine zooplankton. *Mar. Environ. Res.* 4:121-134.

- HEINBOKEL, J. F.  
1978a. Studies on the functional role of tintinnids in the Southern California Bight. I. Grazing and growth rates in laboratory cultures. *Mar. Biol. (Berl.)* 47:177-189.  
1978b. Studies on the functional role of tintinnids in the Southern California Bight. II. Grazing rates of field populations. *Mar. Biol. (Berl.)* 47:191-197.
- HEINBOKEL, J. F., and J. R. BEERS.  
1979. Studies on the functional role of tintinnids in the Southern California Bight. III. Grazing impact of natural assemblages. *Mar. Biol. (Berl.)* 52:23-32.
- HEINLE, D. R.  
1969. Culture of calanoid copepods in synthetic sea water. *J. Fish. Res. Board Can.* 26:150-153.  
1970. Population dynamics of exploited cultures of calanoid copepods. *Helgol. wiss. Meeresunters.* 20:360-372.
- HEINLE, D. R., R. P. HARRIS, J. F. USTACH, and D. A. FLEMER.  
1977. Detritus as food for estuarine copepods. *Mar. Biol. (Berl.)* 40:341-353.
- HJORT, J.  
1914. Fluctuations in the great fisheries of northern Europe viewed in the light of biological research. *Rapp. P.-V. Réun. Cons. Int. Explor. Mer* 20:1-228.
- HODGKIN, E. P., and R. J. RIPPINGALE.  
1971. Interspecies conflict in estuarine copepods. *Limnol. Oceanogr.* 16:573-576.
- HONJO, S., and M. R. ROMAN.  
1978. Marine copepod fecal pellets: Production, preservation and sedimentation. *J. Mar. Res.* 36:45-57.
- HUNTLEY, M. E.  
1981. Nonselective, nonsaturated feeding by three calanid copepod species in the Labrador Sea. *Limnol. Oceanogr.* 26:831-842.  
1982. Yellow water in La Jolla Bay, California, July 1980. II. Suppression of zooplankton grazing. *J. Exp. Mar. Biol. Ecol.* 63:81-91.
- HUREAU, J. C., and Th. MONOD (editors).  
1973. Check-list of the fishes of the north-eastern Atlantic and of the Mediterranean, Vol. I. UNESCO, Paris, 683 p.
- IKEDA, T.  
1971. Preliminary shipboard culture experiments on the feeding and respiration of an oceanic copepod, *Calanus cristatus*, in the Bering Sea. [In Engl.] *Bull. Plankton Soc. Jpn.* 18:5-14.  
1977. Feeding rates of planktonic copepods from a tropical sea. *J. Exp. Mar. Biol. Ecol.* 29:263-277.
- ITOH, K.  
1970. A consideration on feeding habits of planktonic copepods in relation to the structure of their oral parts. [In Jpn., Engl. abstr.] *Bull. Plankton Soc. Jpn.* 17:1-10.
- JOHNSON, G. F.  
1969. A contribution to the biology of *Corycaeus anglicus*, a marine cyclopoid copepod. M.S. Thesis, University of California, San Diego, 68 p.
- JUNE, F. C., and F. T. CARLSON.  
1971. Food of young Atlantic menhaden, *Brevoortia tyrannus*, in relation to metamorphosis. *Fish. Bull., U.S.* 68:493-512.
- KARANDE, A. A.  
1974a. *Balanus variegatus* Darwin: The laboratory reared larvae compared with *Balanus amphitrite amphitrite* Darwin (Cirripedia). *Crustaceana* 26:229-232.  
1974b. Larval development of the barnacle *Tetraclitella karandei* reared in the laboratory. *Biol. Bull. (Woods Hole)* 146:249-257.
- KING, K. R.  
1982. The population biology of the larvacean *Oikopleura dioica* in enclosed water columns. In G. D. Grice and M. R. Reeve (editors), *Marine mesocosms: Biological and chemical research in experimental ecosystems*, p. 341-351. Springer-Verlag, N.Y.
- KING, K. R., J. T. HOLLIBAUGH, and F. AZAM.  
1980. Predator-prey interactions between the larvacean *Oikopleura dioica* and bacterioplankton in enclosed water columns. *Mar. Biol. (Berl.)* 56:49-57.
- KJØRBOE, T., F. MØHLENBERG, and H. NICOLAJSEN.  
1982. Ingestion rate and gut clearance in the planktonic copepod *Centropages hamatus* (Lilljeborg) in relation to food concentration and temperature. *Ophelia* 21:181-194.
- KJELSON, M. A., D. S. PETERS, G. W. THAYER, and G. N. JOHNSON.  
1975. The general feeding ecology of postlarval fishes in the Newport River estuary. *Fish. Bull., U.S.* 73:137-144.
- KLEIN BRETELER, W. C. M.  
1980. Continuous breeding of marine pelagic copepods in the presence of heterotrophic dinoflagellates. *Mar. Ecol. Prog. Ser.* 2:229-233.
- KOEHL, M. A. R., and J. R. STRICKLER.  
1981. Copepod feeding currents: Food capture at low Reynolds number. *Limnol. Oceanogr.* 26:1062-1073.
- KOELLER, P. A., J. E. BARWELL-CLARKE, F. WHITNEY, and M. TAKAHASHI.  
1979. Winter condition of marine plankton populations in Saanich Inlet, B. C., Canada. III. Meso-zooplankton. *J. Exp. Mar. Biol. Ecol.* 37:161-174.
- LALLI, C. M.  
1970. Structure and function of the buccal apparatus of *Clione limacina* (Phipps) with a review of feeding in gymnosomatous pteropods. *J. Exp. Mar. Biol. Ecol.* 4:101-118.  
1972. Food and feeding of *Paedocione doliiformis* Danforth, a neotenous gymnosomatous pteropod. *Biol. Bull. (Woods Hole)* 143:392-402.
- LAMPITT, R. S.  
1978. Carnivorous feeding by a small marine copepod. *Limnol. Oceanogr.* 23:1228-1231.
- LAMPITT, R. S., and J. C. GAMBLE.  
1982. Diet and respiration of the small planktonic marine copepod *Oithona nana*. *Mar. Biol. (Berl.)* 66:185-190.
- LANDRY, M. R.  
1978. Population dynamics and production of a planktonic marine copepod, *Acartia clausii*, in a small temperate lagoon on San Juan Island, Washington. *Int. Rev. Gesamten Hydrobiol.* 63:77-119.  
1980. Detection of prey by *Calanus pacificus*: Implications of the first antennae. *Limnol. Oceanogr.* 25:545-549.  
1981. Switching between herbivory and carnivory by the planktonic marine copepod *Calanus pacificus*. *Mar. Biol. (Berl.)* 65:77-82.
- LAROCHE, J. L.  
1982. Trophic patterns among larvae of five species of sculpins (Family: Cottidae) in a Maine estuary. *Fish. Bull., U.S.* 80:827-840.
- LASKER, R.  
1975. Field criteria for survival of anchovy larvae: The relation between inshore chlorophyll maximum layers and successful first feeding. *Fish. Bull., U.S.* 73:453-462.  
1978. The relation between oceanographic conditions and larval anchovy food in the California Current: Identification of factors contributing to recruitment failure. *Rapp. P.-V. Réun. Cons. Int. Explor. Mer* 173:212-230.  
1981. Factors contributing to variable recruitment of the northern anchovy (*Engraulis mordax*) in the California Current: Contrasting years, 1975 through 1978. *Rapp. P.-V. Réun. Cons. Int. Explor. Mer* 178:375-388.
- LASKER, R., H. M. FEDER, G. H. THEILACKER, and R. C. MAY.  
1970. Feeding, growth, and survival of *Engraulis mordax* larvae reared in the laboratory. *Mar. Biol. (Berl.)* 5:345-353.
- LAST, J. M.  
1978a. The food of four species of pleuronectiform larvae in the eastern English Channel and southern North Sea. *Mar. Biol. (Berl.)* 45:359-368.  
1978b. The food of three species of gadoid larvae in the eastern English Channel and southern North Sea. *Mar. Biol. (Berl.)* 48:377-386.  
1979. The food of larval turbot *Scophthalmus maximus* L. from the west central North Sea. *J. Cons. Int. Explor. Mer* 38:308-313.
- LEBOUR, M. V.  
1918. The food post-larval fish. *J. Mar. Biol. Assoc. U.K.* 11:433-469.  
1919. The food of post-larval fish. No. II (1918). *J. Mar. Biol. Assoc. U.K.* 12:22-47.  
1920. The food of young fish. No. III (1919). *J. Mar. Biol. Assoc. U.K.* 12:261-324.  
1921. The food of young clupeoids. *J. Mar. Biol. Assoc. U.K.* 12:458-467.  
1922. The food of plankton organisms. *J. Mar. Biol. Assoc. U.K.* 12:644-677.
- LONSDALE, D. J.  
1981. Regulatory role of physical factors and predation for two Chesapeake Bay copepod species. *Mar. Ecol. Prog. Ser.* 5:341-351.
- LONSDALE, D. J., D. R. HEINLE, and C. SIEGFRIED.  
1979. Carnivorous feeding behavior of the adult calanoid copepod *Acartia tonsa* Dana. *J. Exp. Mar. Biol. Ecol.* 36:235-248.
- LOWNDES, A. G.  
1935. The swimming and feeding of certain Calanoid Copepods. *Proc. Zool. Soc. Lond.* 1935:687-715.
- MAPSTONE, G. M.  
1970. Feeding activities of veligers of *Nassarius recticulatus* and *Crepidula fornicata* and the use of artificial foods in maintaining cultures of these larvae. *Helgol. wiss. Meeresunters.* 20:565-575.
- MARAK, R. R.  
1960. Food habits of larval cod, haddock, and coalfish in the Gulf of Maine and Georges Bank area. *J. Cons. Int. Explor. Mer* 25:147-157.

1974. Food and feeding of larval redfish in the Gulf of Maine. In J. H. S. Blaxter (editor), *The early life history of fish*, p. 267-275. Springer-Verlag, N.Y.
- MARSHALL, S. M.  
1924. The food of *Calanus finmarchicus* during 1923. *J. Mar. Biol. Assoc. U.K.* 13:473-479.  
1949. On the biology of the small copepods in Loch Striven. *J. Mar. Biol. Assoc. U.K.* 28:45-122.  
1973. Respiration and feeding in copepods. *Adv. Mar. Biol.* 11:57-120.
- MARSHALL, S. M., and A. P. ORR.  
1952. On the biology of *Calanus finmarchicus*. VII. Factors affecting egg production. *J. Mar. Biol. Assoc. U.K.* 30:527-548.  
1955a. On the biology of *Calanus finmarchicus*. VIII. Food uptake, assimilation and excretion in adult and stage V *Calanus*. *J. Mar. Biol. Assoc. U.K.* 34:495-529.  
1955b. Experimental feeding of the copepod *Calanus finmarchicus* (Gunner) on phytoplankton cultures labelled with radioactive carbon ( $^{14}\text{C}$ ). *Deep-Sea Res.* 3 (suppl.):110-114.  
1955c. The biology of a marine copepod, *Calanus finmarchicus* (Gunnerus). Oliver & Boyd, Edinburgh, 188 p.  
1956. On the biology of *Calanus finmarchicus*. IX. Feeding and digestion in the young stages. *J. Mar. Biol. Assoc. U.K.* 35:587-603.  
1958. On the biology of *Calanus finmarchicus*. X. Seasonal changes in oxygen consumption. *J. Mar. Biol. Assoc. U.K.* 37:459-472.  
1961. On the biology of *Calanus finmarchicus*. XII. The phosphorus cycle: Excretion, egg production, autolysis. *J. Mar. Biol. Assoc. U.K.* 41:463-483.  
1966. Respiration and feeding in some small copepods. *J. Mar. Biol. Assoc. U.K.* 46:513-530.
- MAYZAUD, P., and S. A. POULET.  
1978. The importance of the time factor in the response of zooplankton to varying concentrations of naturally occurring particulate matter. *Limnol. Oceanogr.* 23:1144-1154.
- McALLISTER, C. D.  
1970. Zooplankton rations, phytoplankton mortality and the estimation of marine production. In J. H. Steele (editor), *Marine food chains*, p. 419-457. Oliver & Boyd, Edinburgh.
- MENDIOLA, B. R. de.  
1969. The food of the Peruvian anchovy. *J. Cons. Int. Explor. Mer* 32: 433-434.  
1974. Food of the larval anchoveta *Engraulis ringens* J. In J. H. S. Blaxter (editor), *The early life history of fish*, p. 277-285. Springer-Verlag, N.Y.
- MORTON, J. E.  
1954. The biology of *Limacina retroversa*. *J. Mar. Biol. Assoc. U.K.* 33: 297-312.
- MOYSE, J.  
1960. Mass rearing of barnacle cyprids in the laboratory. *Nature (Lond.)* 185:120.  
1963. A comparison of the value of various flagellates and diatoms as food for barnacle larvae. *J. Cons. Int. Explor. Mer* 28:175-187.
- MULLIN, M. M.  
1963. Some factors affecting the feeding of marine copepods of the genus *Calanus*. *Limnol. Oceanogr.* 8:239-250.
- MULLIN, M. M., and E. R. BROOKS.  
1967. Laboratory culture, growth rate, and feeding behavior of a planktonic marine copepod. *Limnol. Oceanogr.* 12:657-666.  
1970a. Growth and metabolism of two planktonic, marine copepods as influenced by temperature and type of food. In J. H. Steele (editor), *Marine food chains*, p. 74-95. Oliver & Boyd, Edinburgh.  
1970b. The effect of concentration of food on body weight, cumulative ingestion, and rate of growth of the marine copepod *Calanus helgolandicus*. *Limnol. Oceanogr.* 15:748-755.
- MURPHY, H. E.  
1923. The life cycle of *Oithona nana* reared experimentally. *Univ. Calif. Publ. Zool.* 22:449-454.
- NASSOGNE, A.  
1970. Influence of food organisms on the development and culture of pelagic copepods. *Helgol. wiss. Meeresunters.* 20:333-345.
- NEUNES, H. W., and G.-F. PONGOLINI.  
1965. Breeding a pelagic copepod, *Euterpina acutifrons* (Dana), in the laboratory. *Nature (Lond.)* 208:571-573.
- NIVAL, P., and S. NIVAL.  
1976. Particle retention efficiencies of an herbivorous copepod, *Acartia clausi* (adult and copepodite stages): Effects on grazing. *Limnol. Oceanogr.* 21:24-38.
- NIVAL, S., and S. RAVERA.  
1979. Morphological study of the appendages of the marine cladoceran *Evadne spinifera* by means of the scanning electron microscope. *J. Plankton Res.* 1:207-213.
- O'CONNORS, H. B., Jr., D. C. BIGGS, and D. V. NINIVAGGI.  
1980. Particle-size-dependant maximum grazing rates for *Temora longicornis* fed natural particle assemblages. *Mar. Biol. (Berl.)* 56:65-70.
- O'CONNORS, H. B., L. F. SMALL, and P. L. DONAGHAY.  
1976. Particle-size modification by two size classes of the estuarine copepod *Acartia clausi*. *Limnol. Oceanogr.* 21:300-308.
- OGILVIE, H. S.  
1927. Observations on the food of post-larval herring from the Scottish coast. *Rep. Fish. Board Scotl.* 1:1-10.  
1938. The food of post-larval haddock with reference to the annual fluctuations in the haddock broods. *Rapp. P.-V. Réun. Cons. Int. Explor. Mer* 107: 57-66.
- OMORI, M.  
1973. Cultivation of marine copepods. [In Jpn., Engl. abstr.] *Bull. Plankton Soc. Jpn.* 20:3-11.
- ONBE, T.  
1977. The biology of marine cladocerans in a warm temperate water. In *Proceedings of the symposium on warm water zooplankton*, p. 383-398. Nat. Inst. Oceanogr., Goa.
- PAFFENHÖFER, G.-A.  
1970. Cultivation of *Calanus helgolandicus* under controlled conditions. *Helgol. wiss. Meeresunters.* 20:346-359.  
1971. Grazing and ingestion rates of nauplii, copepodids and adults of the marine planktonic copepod *Calanus helgolandicus*. *Mar. Biol. (Berl.)* 11: 286-298.  
1972. The effects of suspended 'red mud' on mortality, body weight, and growth of the marine planktonic copepod, *Calanus helgolandicus*. *Water Air Soil Pollut.* 1:314-321.  
1973. The cultivation of an appendicularian through numerous generations. *Mar. Biol. (Berl.)* 22:183-185.  
1976a. Feeding, growth, and food conversion of the marine planktonic copepod *Calanus helgolandicus*. *Limnol. Oceanogr.* 21:39-50.  
1976b. Continuous and nocturnal feeding of the marine planktonic copepod *Calanus helgolandicus*. *Bull. Mar. Sci.* 26:49-58.  
1976c. On the biology of appendicularia of the southeastern North Sea. In G. Persoone and E. Jaspers (editors), *Proc. 10th Europ. Symp. Mar. Biol., Ostend, Belgium, Sept. 17-23, 1975, Vol. 2*, p. 437-455. Universa Press, Wetteren, Belg.  
1982. Grazing by copepods in the Peru upwelling. *Deep-Sea Res.* 29: 145-146.
- PAFFENHÖFER, G.-A., and R. P. HARRIS.  
1976. Feeding, growth and reproduction of the marine planktonic copepod *Pseudocalanus elongatus* Boeck. *J. Mar. Biol. Assoc. U.K.* 56:327-344.
- PAFFENHÖFER, G.-A., and S. C. KNOWLES.  
1978. Feeding of marine planktonic copepods on mixed phytoplankton. *Mar. Biol. (Berl.)* 48:143-152.  
1979. Ecological implications of fecal pellet size, production and consumption by copepods. *J. Mar. Res.* 37:35-49.  
1980. Omnivorousness in marine planktonic copepods. *J. Plankton Res.* 2:355-365.
- PAFFENHÖFER, G.-A., and J. D. H. STRICKLAND.  
1970. A note on the feeding of *Calanus helgolandicus* on detritus. *Mar. Biol. (Berl.)* 5:97-99.
- PAFFENHÖFER, G.-A., J. R. STRICKER, and M. ALCARAZ.  
1982. Suspension-feeding by herbivorous calanoid copepods: A cinematographic study. *Mar. Biol. (Berl.)* 67:193-199.
- PARANJAPE, M. A.  
1968. The egg mass and veligers of *Limacina helicina* Phipps. *The Veliger* 10:322-326.
- PARRISH, K. K., and D. F. WILSON.  
1978. Fecundity studies on *Acartia tonsa* (Copepoda: Calanoida) in standardized culture. *Mar. Biol. (Berl.)* 46:65-81.
- PARSONS, T. R., and M. TAKAHASHI.  
1973. Biological oceanographic processes. Pergamon, Oxford, 186 p.
- PAVLOVA, E. V.  
1959. On the feeding of *Penilia avirostris*. *Tr. Sevastopol Biol. Stn.* 11: 63-71. (Engl. transl., *Fish. Res. Board Can. Transl.* 967, 18 p.)  
1967. Food utilization and energy conversion by Black Sea Cladocera populations. *Biol. Morya* 4:66-85. (Engl. transl., *Fish. Res. Board Can. Transl.* 974, 34 p.)
- PAVLOVA, E. V., T. S. PETIPA, and Yu. I. SOROKIN.  
1973. Bacterioplankton as food for pelagic marine organisms. In M. E. Vinogradov (editor), *Life activity of pelagic communities in the ocean tropics*, p. 156-165. Israel Program for Scientific Translations, Jerusalem.

- PAVLOVA, E. V., and Y. I. SOROKIN.  
1970. Feeding on bacteria by the planktonic crustacean *Penilia avirostris* Dana in the Black Sea. [In Russ.] Biol. Morya 19:182-197.
- PEARCY, W. G.  
1962. Ecology of an estuarine population of winter flounder, *Pseudopleuronectes americanus* (Walbaum). Bull. Bingham Oceanogr. Collect. Yale Univ. 18:5-78.
- PETIPA, T. S., E. V. PAVLOVA, and G. N. MIRONOV.  
1970. The food web structure, utilization and transport of energy by trophic levels in the planktonic communities. In J. H. Steele (editor), Marine food chains, p. 142-167. Oliver & Boyd, Edinburgh.
- PETIPA, T. S., E. V. PAVLOVA, and Yu. I. SOROKIN.  
1973. Radiocarbon studies of the feeding of mass plankton forms in the tropical zone of the Pacific. In M. E. Vinogradov (editor), Life activity of pelagic communities in the ocean tropics, p. 135-155. Israel Program for Scientific Translations, Jerusalem.
- PILKINGTON, M. C., and V. FRETTER.  
1970. Some factors affecting the growth of prosobranch veligers. Helgol. wiss. Meeresunters. 20:576-593.
- PIONTKOVSKI, S. A., and T. S. PETIPA.  
1976. Quantitative description of the behavior of copepod *Acartia clausi* during feeding on algae. Sov. J. Mar. Biol. (Engl. transl. Biol. Morya) 2:40-46.
- POMEROY, L. R.  
1974. The ocean's food web, a changing paradigm. BioScience 24:499-504.
- POULET, S. A.  
1973. Grazing of *Pseudocalanus minutus* on naturally occurring particulate matter. Limnol. Oceanogr. 18:564-573.  
1974. Seasonal grazing of *Pseudocalanus minutus* on particles. Mar. Biol. (Berl.) 25:109-123.  
1976. Feeding of *Pseudocalanus minutus* on living and non-living particles. Mar. Biol. (Berl.) 34:117-125.  
1978. Comparison between five coexisting species of marine copepods feeding on naturally occurring particulate matter. Limnol. Oceanogr. 23:1126-1143.
- POULET, S. A., and P. MARSOT.  
1978. Chemosensory grazing by marine calanoid copepods (Arthropoda: Crustacea). Science (Wash., D.C.) 200:1403-1405.  
1980. Chemosensory feeding and food-gathering by omnivorous copepods. In W. C. Kerfoot (editor), Evolution and ecology of zooplankton communities, p. 198-218. University Press of New England, Hanover, N.H.
- PRICE, H. J., G.-A. PAFFENHÖFER, and J. R. STRICKLER.  
1983. Modes of cell capture in calanoid copepods. Limnol. Oceanogr. 28:116-123.
- RASSOULZADEGAN, F., and M. ETIENNE.  
1981. Grazing rate of the tintinnid *Stenosemella ventricosa* (Clap. & Lachm.) Jörg. on the spectrum of the naturally occurring particulate matter from a Mediterranean neritic area. Limnol. Oceanogr. 26:258-270.
- RAYMONT, J. E. G.  
1959. The respiration of some planktonic copepods. III. The oxygen requirements of some American species. Limnol. Oceanogr. 4:479-491.
- REEVE, M. R., and M. A. WALTER.  
1977. Observations on the existence of lower threshold and upper critical food concentrations for the copepod *Acartia tonsa* Dana. J. Exp. Mar. Biol. Ecol. 29:211-221.
- RICHMAN, S., D. R. HEINLE, and R. HUFF.  
1977. Grazing by adult estuarine calanoid copepods of the Chesapeake Bay. Mar. Biol. (Berl.) 42:69-84.
- RICHMAN, S., Y. LOYA, and L. B. SLOBODKIN.  
1975. The rate of mucus production by corals and its assimilation by the coral reef copepod *Acartia negligens*. Limnol. Oceanogr. 20:918-923.
- RICHMAN, S., and J. N. ROGERS.  
1969. The feeding of *Calanus helgolandicus* on synchronously growing populations of the marine diatom *Dietylum brightwellii*. Limnol. Oceanogr. 14:701-709.
- RIEPEL, M.  
1978. Bacteria as food for marine harpacticoid copepods. Mar. Biol. (Berl.) 45:337-345.  
1982. Feeding preferences of marine harpacticoid copepods for various species of bacteria. Mar. Ecol. Prog. Ser. 7:303-307.
- RIEPEL, M., and C. FLOTOW.  
1981. Feeding experiments with bacteria, ciliates and harpacticoid copepods. Kiel. Meeresforsch. Sonderh. 5:370-375.
- RILEY, G. A.  
1946. Factors controlling phytoplankton populations on Georges Bank. J. Mar. Res. 6:54-73.
- RIPPINGALE, R. J., and E. P. HODGKIN.  
1975. Predation effects on the distribution of a copepod. Aust. J. Mar. Freshw. Res. 26:81-91.
- ROBERTSON, J. R.  
1983. Predation by estuarine zooplankton on tintinnid ciliates. Estuarine Coastal Shelf Sci. 16:27-36.
- ROBINS, C. R., R. M. BAILEY, C. E. BOND, J. R. BROOKER, E. A. LACHNER, R. N. LEA, and W. B. SCOTT (editors).  
1980. A list of common and scientific names of fishes from the United States and Canada. 4th ed. Am. Fish. Soc. Spec. Publ. 12, 174 p.
- ROMAN, M. R.  
1977. Feeding of the copepod *Acartia tonsa* on the diatom *Nitzschia closterium* and brown algae (*Fucus vesiculosus*) detritus. Mar. Biol. (Berl.) 42:149-155.  
1978. Ingestion of the blue-green alga *Trichodesmium* by the harpacticoid copepod, *Macrosetella gracilis*. Limnol. Oceanogr. 23:1245-1248.
- ROMAN, M. R., and P. A. RUBLEE.  
1980. Containment effects in copepod grazing experiments: A plea to end the black box approach. Limnol. Oceanogr. 25:982-990.
- ROSE, M.  
1933. Copépodes pélagiques. Faune Fr. 26, 374 p.
- ROSENBERG, G. G.  
1980. Filmed observations of filter feeding in the marine planktonic copepod *Acartia clausii*. Limnol. Oceanogr. 25:738-742.
- RUNGE, J. A.  
1980. Effects of hunger and season on the feeding behavior of *Calanus pacificus*. Limnol. Oceanogr. 25:134-145.
- RYLAND, J. S.  
1964. The feeding of plaice and sand-eel larvae in the southern North Sea. J. Mar. Biol. Assoc. U.K. 44:343-364.
- RYTHER, J. H., and J. G. SANDERS.  
1980. Experimental evidence of zooplankton control of the species composition and size distribution of marine phytoplankton. Mar. Ecol. Prog. Ser. 3:279-283.
- SCHNACK, S. B.  
1979. Feeding of *Calanus helgolandicus* on phytoplankton mixtures. Mar. Ecol. Prog. Ser. 1:41-47.  
1983. On the feeding of copepods on *Thalassiosira partheneia* from the Northwest African upwelling area. Mar. Ecol. Prog. Ser. 11:49-53.
- SEKI, H.  
1973. Red tide of *Oikopleura* in Saanich Inlet. La Mer (Bull. Soc. Franco-Jpn. Oceanogr.) 11:153-158.
- SHELBOURNE, J. E.  
1953. The feeding habits of plaice post-larvae in the Southern Bight. J. Mar. Biol. Assoc. U.K. 32:149-159.  
1957. The feeding and condition of plaice larvae in good and bad plankton patches. J. Mar. Biol. Assoc. U.K. 36:539-552.  
1962. A predator-prey size relationship for plaice larvae feeding on *Oikopleura*. J. Mar. Biol. Assoc. U.K. 42:243-252.
- SHERMAN, K., and K. A. HONEY.  
1971. Seasonal variations in the food of larval herring in coastal waters of central Maine. Rapp. P.-V. Réun. Cons. Int. Explor. Mer 160:121-124.
- SILVER, M. W., and K. W. BRULAND.  
1981. Differential feeding and fecal pellet composition of salps and pteropods, and the possible origin of the deep-water flora and olive-green "cells." Mar. Biol. (Berl.) 62:263-273.
- SMITH, S. L., and B. K. HALL.  
1980. Transfer of radioactive carbon within the copepod *Temora longicornis*. Mar. Biol. (Berl.) 55:277-286.
- SOROKIN, Yu. I.  
1973. Quantitative evaluation of the role of bacterioplankton in the biological productivity of tropical Pacific waters. In M. E. Vinogradov (editor), Life activity of pelagic communities in the ocean tropics, p. 98-134. Israel Program for Scientific Translations, Jerusalem.  
1981. Microheterotrophic organisms in marine ecosystems. In A. R. Longhurst (editor), Analysis of marine ecosystems, p. 293-342. Acad. Press, N.Y.
- SOROKIN, Yu. I., T. S. PETIPA, and Ye. V. PAVLOVA.  
1970. Quantitative estimate of marine bacterioplankton as a source of food. Oceanology 10:253-260.
- SPITTLER, P.  
1973. Feeding experiments with tintinnids. Oikos 15 (suppl):128-132.
- STOECKER, D., R. R. L. GUILLARD, and R. M. KAVEE.  
1981. Selective predation by *Favella ehrenbergii* (Tintinnia) on and among dinoflagellates. Biol. Bull. (Woods Hole) 160:136-145.
- STRICKLER, J. R.  
1982. Calanoid copepods, feeding currents, and the role of gravity. Science



- (Wash., D.C.) 218:158-160.
- SUMIDA, B. Y., and H. G. MOSER.  
1980. Food and feeding of Pacific hake larvae, *Merluccius productus*, off southern California and northern Baja California. Calif. Coop. Oceanic Fish. Invest. Rep. 21:161-166.
- SYSOEVA, T. K., and A. A. DEGREVA.  
1965. The relation between the feeding of cod larvae and pelagic fry and the distribution and abundance of their principal food organisms. ICNAF Spec. Publ. 6, p. 411-416. Dartmouth, N.S., Canada.
- TAGUCHI, S., and H. ISHII.  
1972. Shipboard experiments on respiration, excretion, and grazing of *Calanus cristatus* and *C. plumchrus* (Copepoda) in the northern North Pacific. In A. Y. Takenouti (chief editor), Biological oceanography of the northern North Pacific Ocean, p. 419-431. Idemitsu Shoten, Tokyo.
- TESTER, P. A.  
1982. The effects of the temperature acclimation of parental generations and incubation temperature on lability of egg hatching time in the copepod *Acartia tonsa* Dana. Ph.D. Thesis, Oregon State University, Corvallis, 53 p.
- THOMPSON, T. E.  
1959. Feeding in nudibranch larvae. J. Mar. Biol. Assoc. U.K. 38:239-248.
- TIGHE-FORD, D. J., M. J. D. POWER, and D. C. VAILE.  
1970. Laboratory rearing of barnacle larvae for antifouling research. Helgol. wiss. Meeresunters. 20:393-405.
- TIMONIN, A. G.  
1969. The structure of pelagic associations. The quantitative relationship between different trophic groups of plankton in frontal zones of the tropical ocean. Oceanology 9:686-695.  
1971. The structure of plankton communities of the Indian Ocean. Mar. Biol. (Berl.) 9:281-289.
- TOMAS, C. R., and E. E. DEASON.  
1981. The influence of grazing by two *Acartia* species on *Olisthodiscus luteus*. Pubbl. Stn. Zool. Napoli I: Marine Ecology 2:215-223.
- TOMASINI, J. A., and J. MAZZA.  
1978. Comportement alimentaire de deux copépodes calanoides (*Centropages typicus* et *Acartia clausi*) en milieu nutritifs à une seule algue. J. Cons. Int. Explor. Mer 38:154-179.
- TURNER, J. T.  
1978. Scanning electron microscope investigations of feeding habits and mouthpart structures of three species of copepods of the Family Pontellidae. Bull. Mar. Sci. 28:487-500.  
1981. Latitudinal patterns of calanoid and cyclopoid copepod diversity in estuarine waters of eastern North America. J. Biogeogr. 8:369-382.  
1982. The annual cycle of zooplankton in a Long Island estuary. Estuaries 5:261-274.
- TURNER, J. T., and D. M. ANDERSON.  
1983. Zooplankton grazing during dinoflagellate blooms in a Cape Cod embayment, with observations of predation upon tintinnids by copepods. Pubbl. Stn. Zool. Napoli I: Marine Ecology 4:359-374.
- UOTANI, I., K. MATSUZAKI, Y. MAKINO, K. NODA, O. INAMURA, and M. HORIKAWA.  
1981. Food habits of larvae of tunas and their related species in the area northwest of Australia. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 47: 1165-1172.
- UYE, S.-I.  
1980a. Development of neritic copepods *Acartia clausi* and *A. steueri*. I. Some environmental factors affecting egg development and the nature of resting eggs. Bull. Plankton Soc. Jpn. 27:1-9.  
1980b. Development of neritic copepods *Acartia clausi* and *A. steueri*. II. Isochronal larval development at various temperatures. Bull. Plankton Soc. Jpn. 27:11-18.
1981. Fecundity studies of neritic calanoid copepods *Acartia clausi* Giesbrecht and *A. steueri* Smirnov: A simple empirical model of daily egg production. J. Exp. Mar. Biol. Ecol. 50:255-271.
- VERITY, P. G., and D. STOECKER.  
1982. Effects of *Olisthodiscus luteus* on the growth and abundance of tintinnids. Mar. Biol. (Berl.) 72:79-87.
- VIDAL, J.  
1980a. Physioecology of zooplankton. I. Effects of phytoplankton concentration, temperature, and body size on the growth rate of *Calanus pacificus* and *Pseudocalanus* sp. Mar. Biol. (Berl.) 56:111-134.  
1980b. Physioecology of zooplankton. II. Effects of phytoplankton concentration, temperature, and body size on the development and molting rates of *Calanus pacificus* and *Pseudocalanus* sp. Mar. Biol. (Berl.) 56:135-146.
- WALKER, L. M.  
1981. Reproductive biology and development of a marine harpacticoid copepod reared in the laboratory. J. Crustacean Biol. 1:376-388.
- WEISS, T.  
1983. Feeding of calanoid copepods in relation to *Phaeocystis pouchetii* blooms in the German Wadden Sea area off Sylt. Mar. Biol. (Berl.) 74: 87-94.
- WHITE, A. W.  
1977. Dinoflagellate toxins as probable cause of an Atlantic herring (*Clupea harengus harengus*) kill, and pteropods as apparent vector. J. Fish. Res. Board Can. 34:2421-2424.  
1980. Recurrence of kills of Atlantic herring (*Clupea harengus harengus*) caused by dinoflagellate toxins transferred through herbivorous zooplankton. Can. J. Fish. Aquat. Sci. 37:2262-2265.  
1981. Marine zooplankton can accumulate and retain dinoflagellate toxins and cause fish kills. Limnol. Oceanogr. 26:103-109.
- WHITE, H. H.  
1979. Effects of dinoflagellate bioluminescence on the ingestion rates of herbivorous zooplankton. J. Exp. Mar. Biol. Ecol. 36:217-224.
- WICKSTEAD, J. H.  
1962. Food and feeding in pelagic copepods. Proc. Zool. Soc. Lond. 139: 545-555.
- WIEBE, P. H., L. P. MADIN, L. R. HAURY, G. R. HARBISON, and L. M. PHILBIN.  
1979. Diel vertical migration by *Salpa aspera* and its potential for large-scale particulate organic matter transport to the deep-sea. Mar. Biol. (Berl.) 53:249-255.
- WISELY, B.  
1960. Experiments on rearing the barnacle *Eliminius modestus* Darwin to settling stage in the laboratory. Aust. J. Mar. Freshw. Res. 11:42-54.
- WYATT, T.  
1974. The feeding of plaice and sand-eel larvae in the Southern Bight in relation to the distribution of their food organisms. In J. H. S. Blaxter (editor), The early life history of fish, p. 245-251. Springer-Verlag, N.Y.
- YONGE, C. M.  
1926. Ciliary feeding mechanisms in the thecosomatous pteropods. J. Linn. Soc. Lond., Zool. 36:417-429.
- ZILLIOUX, E. J.  
1969. A continuous recirculating culture system for planktonic copepods. Mar. Biol. (Berl.) 4:215-218.
- ZILLIOUX, E. J., and D. F. WILSON.  
1966. Culture of a planktonic calanoid copepod through multiple generations. Science (Wash., D.C.) 151:996-998.
- ZURLINI, G., I. FERRARI, and A. NASSOGNE.  
1978. Reproduction and growth of *Euterpina acutifrons* (Copepoda:Harpacticoida) under experimental conditions. Mar. Biol. (Berl.) 46:59-64.

Appendix Table 1.—Species of fish whose larvae have been reported to eat copepod nauplii.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>			
<i>Anchoa mitchelli</i>	Detwyler and Houde (1970)	<i>Sebastes marinus</i>	Marak (1974)
<i>Brevortia patronus</i>	Govoni et al. (1983)	<i>Scomber scomber</i>	Lebour (1918, 1920)
<i>B. tyrannus</i>	Kjelson et al. (1975)	<i>Thunnus alalunga</i>	Uotani et al. (1981)
<i>Clupea harengus</i>	Bainbridge and Forsyth (1971)	<i>T. albacares</i>	Uotani et al. (1981)
<i>Clupea harengus</i>	Bjørke (1971, 1978)	<i>T. maccoyii</i>	Uotani et al. (1981)
<i>Clupea harengus</i>	Bowers and Williamson (1951)	<i>T. obesus</i>	Uotani et al. (1981)
<i>Clupea harengus</i>	Gamble et al. (1981)	<i>Trachinus vipera</i>	Lebour (1918, 1919, 1920)
<i>Clupea harengus</i>	Lebour (1918, 1919, 1920, 1921)	<i>Trachurus symmetricus</i>	Arthur (1976)
<i>Clupea harengus</i>	Ogilvie (1927)	<i>T. trachurus</i>	Lebour (1920)
<i>Clupea harengus</i>	Sherman and Honey (1971)	<i>Triglops murrayi</i>	Laroche (1982)
<i>Engraulis anchoita</i>	Ciechomski (1967)	<b>PLEURONECTIFORMES</b>	
<i>E. mordax</i>	Arthur (1976)	<i>Limanda limanda</i>	Last (1978a)
<i>E. ringens</i>	Mendiola (1974)	<i>Limanda limanda</i>	Lebour (1920)
<i>Harengula pensacolatae</i>	Detwyler and Houde (1970)	<i>Microstomus kitt</i>	Lebour (1920)
<i>Sardina pilchardus</i>	Lebour (1920, 1921)	<i>Phrynorhombus norvegicus</i>	Lebour (1918, 1920)
<i>Sardinops sagax</i>	Arthur (1976)	<i>Platichthys flesus</i>	Last (1978a)
<i>Sprattus sprattus</i>	Lebour (1918, 1921)	<i>Pleuronectes platessa</i>	Last (1978a)
<b>PERCIFORMES</b>			
<i>Ammodytes americanus</i>	Covill (1959)	<i>Pleuronectes platessa</i>	Ryland (1964)
<i>A. marinus</i>	Ryland (1964)	<i>Pleuronectes platessa</i>	Shelbourne (1953)
<i>A. marinus</i>	Wyatt (1974)	<i>Pleuronectes platessa</i>	Wyatt (1974)
<i>A. tobianus</i>	Lebour (1918, 1919, 1920)	<i>Psetta maxima</i>	Lebour (1920)
<i>Auxis</i> sp.	Uotani et al. (1981)	<i>Pseudopleuronectes</i>	
<i>Callionymus lyra</i>	Lebour (1920)	<i>americanus</i>	Pearcy (1962)
<i>Ctenolabrus rupestris</i>	Lebour (1920)	<i>Scophthalmus maximus</i>	Last (1979)
<i>Eutrigla gurnardus</i>	Lebour (1920)	<i>S. rhombus</i>	Lebour (1920)
<i>Gobius niger</i>	Lebour (1920)	<i>Solea solea</i>	Last (1978a)
<i>Gobiusculus flavescens</i>	Lebour (1918, 1920)	<b>GADIFORMES</b>	
<i>Katsuwonus pelamis</i>	Uotani et al. (1981)	<i>Ciliata mustela</i>	Lebour (1918, 1920)
<i>Labrus bergylla</i>	Lebour (1918, 1919, 1920)	<i>Gadus morhua</i>	Ellertsen et al. (1981); Last (1978b); Marak (1960); Sysoeva and Degtereva (1965)
<i>L. bimaculatus</i>	Lebour (1920)	<i>Melanogrammus aeglefinus</i>	Marak (1960)
<i>Lagodon rhomboides</i>	Kjelson et al. (1975)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)	<i>Merlangius merlangus</i>	Last (1978b)
<i>Leiostomus xanthurus</i>	Kjelson et al. (1975)	<i>Merlangius merlangus</i>	Lebour (1918, 1919, 1920)
<i>Lepadogaster candollei</i>	Lebour (1918, 1920)	<i>Merluccius merluccius</i>	Lebour (1920)
<i>L. lepadogaster</i>	Lebour (1918)	<i>M. productus</i>	Sumida and Moser (1980)
<i>Micropogonias undulatus</i>	Govoni et al. (1983)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Myoxocephalus aeneus</i>	Laroche (1982)	<i>Molva molva</i>	Lebour (1920)
<i>M. octodecemspinus</i>	Laroche (1982)	<i>Pollachius virens</i>	Marak (1960)
<i>M. scorpius</i>	Laroche (1982)	<i>Trisopterus luscus</i>	Last (1978b)
<i>Pomatoschistus microps</i>	Lebour (1920)		

Appendix Table 2.—Species of fish whose larvae have been reported to eat species of *Acartia*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Anchoa mitchelli</i>	Detwyler and Houde (1970)	<i>Limanda limanda</i>	Lebour (1920)
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Microchirus variegatus</i>	Lebour (1918)
<i>B. tyrannus</i>	June and Carlson (1971)	<i>Phrynorhombus norvegicus</i>	Lebour (1918, 1920)
<i>B. tyrannus</i>	Kjelson et al. (1975)	<i>Platichthys flesus</i>	Lebour (1920)
<i>Clupea harengus</i>	Bowers and Williamson (1951)	<i>Scophthalmus maximus</i>	Last (1979)
<i>Clupea harengus</i>	Gamble et al. (1981)	<i>Solea nasuta</i>	Lebour (1920)
<i>Clupea harengus</i>	Lebour (1920, 1921)	<i>Zeugopterus punctatus</i>	Lebour (1920)
<i>Clupea harengus</i>	Sherman and Honey (1971)		
<i>Harengula pensacolatae</i>	Detwyler and Houde (1970)	<b>GADIFORMES</b>	
<i>Sardina pilchardus</i>	Lebour (1920, 1921)	<i>Ciliata mustela</i>	Lebour (1920)
<b>PERCIFORMES</b>		<i>Gadus morhua</i>	Sysoeva and Degtereva (1965)
<i>Ammodytes americanus</i>	Covill (1959)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>A. tobianus</i>	Lebour (1918, 1920)	<i>Merlangius merlangus</i>	Last (1978b)
<i>Callionymus lyra</i>	Lebour (1919, 1920)	<i>Merlangius merlangus</i>	Lebour (1919, 1920)
<i>Coryphoblennius galerita</i>	Lebour (1919)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Cyclogaster montagui</i>	Lebour (1919)	<i>Pollachius pollachius</i>	Lebour (1918, 1919, 1920)
<i>Gobius niger</i>	Lebour (1918, 1919, 1920)	<i>Trisopterus luscus</i>	Last (1978b)
<i>Gobiusculus flavescens</i>	Lebour (1918, 1919, 1920)	<i>Trisopterus luscus</i>	Lebour (1918, 1920)
<i>Labrus bergylla</i>	Lebour (1919, 1920)	<i>T. minutus</i>	Lebour (1918, 1920)
<i>Lagodon rhomboides</i>	Kjelson et al. (1975)		
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)		
<i>Leiostomus xanthurus</i>	Kjelson et al. (1975)		
<i>Micropogonias undulatus</i>	Govoni et al. (1983)		
<i>Pomatoschistus microps</i>	Lebour (1918, 1919, 1920)		
<i>Thunnus albacares</i>	Uotani et al. (1981)		
<i>Trachurus trachurus</i>	Lebour (1920)		

Appendix Table 3.—Species of fish whose larvae have been reported to eat species of *Calanus*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Clupea harengus</i>	Blaxter (1965)	<i>Arnoglossus</i> sp.	Lebour (1920)
<i>Clupea harengus</i>	Bowers and Williamson (1951)	<i>Limanda limanda</i>	Lebour (1920)
<i>Clupea harengus</i>	Gamble et al. (1981)	<i>Phrynorhombus norvegicus</i>	Lebour (1918, 1920)
<i>Clupea harengus</i>	Ogilvie (1927)	<i>Zeugopterus punctatus</i>	Lebour (1918)
<i>Engraulis ringens</i>	Mendiola (1974)		
<b>PERCIFORMES</b>		<b>GADIFORMES</b>	
<i>Auxis</i> sp.	Uotani et al. (1981)	<i>Gadus morhua</i>	Lebour (1918)
<i>Callionymus lyra</i>	Lebour (1918)	<i>Gadus morhua</i>	Sysoeva and Degtereva (1965)
<i>Crystalllogobius nilssonii</i>	Lebour (1918)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Eutrigla gurnardus</i>	Lebour (1920)	<i>Melanogrammus aeglefinus</i>	Marak (1960)
<i>Sebastes marinus</i>	Bainbridge (1965)	<i>Merlangius merlangus</i>	Lebour (1919, 1920)
<i>Sebastes marinus</i>	Marak (1974)	<i>Merluccius merluccius</i>	Lebour (1920)
<i>Thunnus obesus</i>	Uotani et al. (1981)	<i>M. productus</i>	Sumida and Moser (1980)
<i>Trachurus trachurus</i>	Lebour (1918, 1920)	<i>Micromesistius poutassou</i>	Conway (1980)
		<i>Pollachius pollachius</i>	Lebour (1919, 1920)
		<i>P. virens</i>	Marak (1960)
		<i>Trisopterus luscus</i>	Lebour (1919, 1920)
		<i>T. minutus</i>	Lebour (1920)

Appendix Table 4.—Species of fish whose larvae have been reported to eat species of *Centropages*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Brevoortia tyrannus</i>	June and Carlson (1971)	<i>Arnoglossus</i> sp.	Lebour (1920)
<i>Brevoortia tyrannus</i>	Kjelson et al. (1975)	<i>Psetta maxima</i>	Lebour (1918)
<i>Clupea harengus</i>	Lebour (1921)	<i>Scophthalmus maximus</i>	Last (1979)
<i>Clupea harengus</i>	Ogilvie (1927)	<i>S. rhombus</i>	Lebour (1918)
<i>Engraulis anchoita</i>	Ciechomski (1967)	<b>GADIFORMES</b>	
<b>PERCIFORMES</b>		<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Ammodytes tobianus</i>	Lebour (1920)	<i>Melanogrammus aeglefinus</i>	Marak (1960)
<i>Callionymus lyra</i>	Lebour (1918)	<i>Merlangius merlangus</i>	Lebour (1920)
<i>Lagodon rhomboides</i>	Kjelson et al. (1975)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Leiostomus xanthurus</i>	Kjelson et al. (1975)	<i>Pollachius virens</i>	Marak (1960)
<i>Lepadogaster lepadogaster</i>	Lebour (1918)		
<i>Sebastes marinus</i>	Marak (1974)		
<i>Trachurus trachurus</i>	Lebour (1918, 1920)		

Appendix Table 5.—Species of fish whose larvae have been reported to eat species of *Paracalanus*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Arnoglossus</i> sp.	Lebour (1918)
<i>Clupea harengus</i>	Bowers and Williamson (1951)	<i>Phrynorhombus norvegicus</i>	Lebour (1918, 1920)
<i>Clupea harengus</i>	Lebour (1920, 1921)	<i>P. regias</i>	Lebour (1918)
<i>Clupea harengus</i>	Ogilvie (1927)	<b>GADIFORMES</b>	
<i>Engraulis anchoita</i>	Ciechomski (1967)	<i>Gadus morhua</i>	Last (1978b)
<b>PERCIFORMES</b>		<i>Melanogrammus aeglefinus</i>	Marak (1960)
<i>Ammodytes americanus</i>	Covill (1959)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>A. tobianus</i>	Lebour (1920)	<i>Merlangius merlangus</i>	Last (1978b)
<i>Auxis</i> sp.	Uotani et al. (1981)	<i>Merlangius merlangus</i>	Lebour (1918, 1920)
<i>Callionymus lyra</i>	Lebour (1918, 1920)	<i>Merluccius productus</i>	Sumida and Moser (1980)
<i>Eutrigla gurnardus</i>	Lebour (1920)	<i>Molva molva</i>	Lebour (1920)
<i>Gobiusculus flavescens</i>	Lebour (1920)	<i>Pollachius virens</i>	Marak (1960)
<i>Labrus bergylta</i>	Lebour (1920)	<i>Trisopterus luscus</i>	Last (1978b)
<i>L. bimaculatus</i>	Lebour (1920)		
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)		
<i>Micropogonias undulatus</i>	Govoni et al. (1983)		
<i>Thunnus alalunga</i>	Uotani et al. (1981)		
<i>T. albacares</i>	Uotani et al. (1981)		
<i>T. maccoyii</i>	Uotani et al. (1981)		
<i>T. obesus</i>	Uotani et al. (1981)		
<i>Trachurus trachurus</i>	Lebour (1920)		

Appendix Table 6.—Species of fish whose larvae have been reported to eat species of *Pseudocalanus*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Clupea harengus</i>	Bowers and Williamson (1951)	<i>Arnoglossus</i> sp.	Lebour (1918, 1919, 1920)
<i>Clupea harengus</i>	Gamble et al. (1981)	<i>Limanda limanda</i>	Last (1978a)
<i>Clupea harengus</i>	Lebour (1918, 1919, 1920, 1921)	<i>Limanda limanda</i>	Lebour (1918, 1920)
<i>Clupea harengus</i>	Ogilvie (1927)	<i>Microchirus variegatus</i>	Lebour (1918)
<i>Clupea harengus</i>	Sherman and Honey (1971)	<i>Phrynorhombus norvegicus</i>	Lebour (1918, 1920)
<i>Sardina pilchardus</i>	Lebour (1920, 1921)	<i>P. regias</i>	Lebour (1918)
<i>Sprattus sprattus</i>	Lebour (1918, 1921)	<i>Pleuronectes platessa</i>	Ryland (1964)
<b>PERCIFORMES</b>		<i>Psetta maxima</i>	Ryland (1920)
<i>Agonus cataphractus</i>	Lebour (1920)	<i>Scophthalmus maximus</i>	Last (1979)
<i>Ammodytes americanus</i>	Covill (1959)	<i>Solea nasuta</i>	Lebour (1920)
<i>A. marinus</i>	Ryland (1964)	<b>GADIFORMES</b>	
<i>A. tobianus</i>	Lebour (1918, 1919, 1920)	<i>Gadus morhua</i>	Last (1978b)
<i>Callionymus lyra</i>	Lebour (1918, 1919, 1920)	<i>Gadus morhua</i>	Marak (1960)
<i>Eutrigla gurnardus</i>	Lebour (1920)	<i>Gadus morhua</i>	Sysoeva and Degtereva (1965)
<i>Gobius niger</i>	Lebour (1919, 1920)	<i>Melanogrammus aeglefinus</i>	Marak (1960)
<i>Gobiusculus flavescens</i>	Lebour (1918, 1919, 1920)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Labrus bergylta</i>	Lebour (1918)	<i>Merlangius merlangus</i>	Last (1978b)
<i>L. bimaculatus</i>	Lebour (1920)	<i>Merlangius merlangus</i>	Lebour (1918, 1919, 1920)
<i>Lepadogaster candollei</i>	Lebour (1919, 1920)	<i>Merluccius merluccius</i>	Lebour (1920)
<i>L. lepadogaster</i>	Lebour (1918)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Myoxocephalus scorpius</i>	Laroche (1982)	<i>Molva molva</i>	Lebour (1920)
<i>Pomatoschistus microps</i>	Lebour (1919, 1920)	<i>Pollachius pollachius</i>	Lebour (1919)
<i>Sebastes marinus</i>	Marak (1974)	<i>P. virens</i>	Marak (1960)
<i>Taurulus bubalis</i>	Lebour (1919, 1920)	<i>Trisopterus luscus</i>	Last (1978b)
<i>Trachinus vipera</i>	Lebour (1918, 1919, 1920)	<i>Trisopterus luscus</i>	Lebour (1918, 1919, 1920)
<i>Trachurus trachurus</i>	Lebour (1920)	<i>T. minutus</i>	Lebour (1918, 1920)
<i>Triglops murrayi</i>	Laroche (1982)		

Appendix Table 7.—Species of fish whose larvae have been reported to eat species of *Temora*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Taurulus bubalis</i>	Lebour (1918, 1919, 1920)
<i>B. tyrannus</i>	June and Carlson (1971)	<i>Trachinus vipera</i>	Lebour (1919, 1920)
<i>B. tyrannus</i>	Kjelson et al. (1975)	<i>Trachurus trachurus</i>	Lebour (1919, 1920)
<i>Clupea harengus</i>	Gamble et al. (1981)	<i>Triglops murrayi</i>	Laroche (1982)
<i>Clupea harengus</i>	Ogilvie (1927)	<b>PLEURONECTIFORMES</b>	
<i>Sardina pilchardus</i>	Lebour (1921)	<i>Limanda limanda</i>	Last (1978a)
<b>PERCIFORMES</b>		<i>Limanda limanda</i>	Lebour (1918, 1920)
<i>Agonus cataphractus</i>	Lebour (1920)	<i>Microchirus variegatus</i>	Lebour (1918)
<i>Ammodytes americanus</i>	Covill (1959)	<i>Phrynorhombus norvegicus</i>	Lebour (1918, 1920)
<i>A. tobianus</i>	Lebour (1920)	<i>P. regias</i>	Lebour (1918)
<i>Callionymus lyra</i>	Lebour (1918, 1919, 1920)	<i>Platichthys flessus</i>	Lebour (1920)
<i>Coryphoblennius galerita</i>	Lebour (1918)	<i>Pleuronectes platessa</i>	Last (1978a)
<i>Crystallogobius nilssoni</i>	Lebour (1920)	<i>Pleuronectes platessa</i>	Lebour (1918, 1920)
<i>Ctenolabrus rupestris</i>	Lebour (1919, 1920)	<i>Psetta maxima</i>	Lebour (1918)
<i>Cyclogaster montagui</i>	Lebour (1919)	<i>Scophthalmus maximus</i>	Last (1979)
<i>Diplecogaster bimaculatus</i>	Lebour (1920)	<i>S. rhombus</i>	Lebour (1918, 1920)
<i>Eutrigla gurnardus</i>	Lebour (1920)	<i>Solea nasuta</i>	Lebour (1918, 1920)
<i>Gobius niger</i>	Lebour (1919)	<i>S. solea</i>	Lebour (1918)
<i>Gobiusculus flavescens</i>	Lebour (1918, 1919)	<i>Zeugopterus punctatus</i>	Lebour (1918, 1920)
<i>Labrus bergylta</i>	Lebour (1918, 1919, 1920)	<b>GADIFORMES</b>	
<i>L. bimaculatus</i>	Lebour (1920)	<i>Ciliata mustela</i>	Lebour (1919)
<i>Lagodon rhomboides</i>	Kjelson et al. (1975)	<i>Gadus morhua</i>	Lebour (1918)
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)	<i>Melanogrammus aeglefinus</i>	Marak (1960)
<i>Leiostomus xanthurus</i>	Kjelson et al. (1975)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Lepadogaster candollei</i>	Lebour (1918, 1919, 1920)	<i>Merlangius merlangus</i>	Last (1978b)
<i>Micropogonias undulatus</i>	Govoni et al. (1983)	<i>Merlangius merlangus</i>	Lebour (1919, 1920)
<i>Myoxocephalus aeneus</i>	Laroche (1982)	<i>Pollachius pollachius</i>	Lebour (1918, 1919, 1920)
<i>M. octodecemspinosus</i>	Laroche (1982)	<i>P. virens</i>	Marak (1960)
<i>M. scorpius</i>	Laroche (1982)	<i>Trisopterus luscus</i>	Lebour (1920)
<i>Pomatoschistus microps</i>	Lebour (1920)	<i>T. minutus</i>	Lebour (1920)
<i>Scomber scomber</i>	Lebour (1920)		

Appendix Table 8.—Species of fish whose larvae have been reported to eat species of *Corycaeus*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>			
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Trachurus symmetricus</i>	Arthur (1976)
<i>Clupea harengus</i>	Lebour (1918, 1920, 1921)	<i>T. trachurus</i>	Lebour (1920)
<i>Engraulis anchoita</i>	Ciechomski (1967)	<i>Thunnus alalunga</i>	Uotani et al. (1981)
<b>PERCIFORMES</b>			
<i>Callionymus tyra</i>	Lebour (1918)	<i>T. albacares</i>	Uotani et al. (1981)
<i>Katsuwonus pelamis</i>	Uotani et al. (1981)	<i>T. maccoyii</i>	Uotani et al. (1981)
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)	<i>T. obesus</i>	Uotani et al. (1981)
<i>Micropogonias undulatus</i>	Govoni et al. (1983)	<b>PLEURONECTIFORMES</b>	
<i>Trachinus vipera</i>	Lebour (1919)	<i>Limanda limanda</i>	Lebour (1918)
		<i>Microchirus variegata</i>	Lebour (1918)
		<i>Scophthalmus norvegicus</i>	Lebour (1918)

Appendix Table 9.—Species of fish whose larvae have been reported to eat species of *Oithona*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>			
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Sebastes marinus</i>	Bainbridge (1965)
<i>B. tyrannus</i>	Kjelson et al. (1975)	<i>Sebastes marinus</i>	Marak (1974)
<i>Clupea harengus</i>	Bowers and Williamson (1951)	<i>Thunnus alalunga</i>	Uotani et al. (1981)
<i>Clupea harengus</i>	Gamble et al. (1981)	<i>T. maccoyii</i>	Uotani et al. (1981)
<i>Clupea harengus</i>	Lebour (1918, 1920)	<i>Trachinus vipera</i>	Lebour (1919)
<i>Clupea harengus</i>	Ogilvie (1927)	<i>Trachurus symmetricus</i>	Arthur (1976)
<i>Clupea harengus</i>	Sherman and Honey (1971)	<i>T. trachurus</i>	Lebour (1920)
<i>Engraulis anchoita</i>	Ciechomski (1967)	<b>PLEURONECTIFORMES</b>	
<i>Sardina pilchardus</i>	Lebour (1920, 1921)	<i>Phrynorhombus norvegicus</i>	Lebour (1920)
<b>PERCIFORMES</b>			
<i>Ammodytes americanus</i>	Covill (1959)	<i>Ciliata mustella</i>	Lebour (1919)
<i>A. tobianus</i>	Lebour (1918, 1919, 1920)	<i>Gadus morhua</i>	Sysoeva and Degtereva (1965)
<i>Labrus bergylta</i>	Lebour (1920)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>L. bimaculatus</i>	Lebour (1920)	<i>Merlangius merlangus</i>	Lebour (1920)
<i>Lagodon rhomboides</i>	Kjelson et al. (1975)	<i>Merluccius productus</i>	Sumida and Moser (1980)
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Leiostomus xanthurus</i>	Kjelson et al. (1975)	<i>Pollachius pollachius</i>	Lebour (1919, 1920)
<i>Micropogonias undulatus</i>	Govoni et al. (1983)		
<i>Pomatoschistus microps</i>	Lebour (1920)		

Appendix Table 10.—Species of fish whose larvae have been reported to eat species of *Oncaea*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Microchirus variegatus</i>	Lebour (1918)
<i>Clupea harengus</i>	Lebour (1918)	<i>Phrynorhombus norvegicus</i>	Lebour (1918)
<b>PERCIFORMES</b>		<i>Solea vulgaris</i>	Lebour (1918)
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)	<i>Zeugopterus punctatus</i>	Lebour (1918)
<i>Micropogonias undulatus</i>	Govoni et al. (1983)	<b>GADIFORMES</b>	
<i>Trachurus symmetricus</i>	Arthur (1976)	<i>Merlangius merlangus</i>	Lebour (1918)
		<i>Micromesistius poutassou</i>	Conway (1980)

Appendix Table 11.—Species of fish whose larvae have been reported to eat species of *Euterpina*.

Fish species	Reference	Fish species	Reference
CLUPEIFORMES		<i>Limanda limanda</i>	Lebour (1918)
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Microchirus variegatus</i>	Lebour (1918)
<i>Clupea harengus</i>	Lebour (1918)	<i>Microstomus kitt</i>	Lebour (1918)
<i>Engraulis anchoita</i>	Ciechowski (1967)	<i>Phrynorhombus norvegicus</i>	Lebour (1918)
PERCIFORMES		<i>P. regias</i>	Lebour (1918)
<i>Callionymus lyra</i>	Lebour (1918)	<i>Solea nasuta</i>	Lebour (1918)
<i>Labrus bergylta</i>	Lebour (1918)	<i>S. solea</i>	Lebour (1918)
PLEURONECTIFORMES		<i>Zeugopterus punctatus</i>	Lebour (1918)
<i>Arnoglossus</i> sp.	Lebour (1918)	GADIFORMES	
		<i>Ciliata mustella</i>	Lebour (1919)
		<i>Pollachius pollachius</i>	Lebour (1918)
		<i>Trisopterus minutus</i>	Lebour (1918)

Appendix Table 12.—Species of fish whose larvae have been reported to eat species of *Microsetella*.

Fish species	Reference	Fish species	Reference
CLUPEIFORMES		PLEURONECTIFORMES	
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Microchirus variegatus</i>	Lebour (1918)
<i>Clupea harengus</i>	Bjorke (1971, 1978)	<i>Solea solea</i>	Last (1978a)
<i>Clupea harengus</i>	Ogilvie (1927)	GADIFORMES	
PERCIFORMES		<i>Micromesistius poutassou</i>	Conway (1980)
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)		
<i>Micropogonias undulatus</i>	Govoni et al. (1983)		
<i>Myoxocephalus aeneus</i>	Laroche (1982)		
<i>M. octodecemspinosus</i>	Laroche (1982)		
<i>M. scorpius</i>	Laroche (1982)		
<i>Trachurus symmetricus</i>	Arthur (1976)		

Appendix Table 13.—Species of fish whose larvae have been reported to eat other (mostly unidentified) harpacticoid copepods.

Fish species	Reference	Fish species	Reference
CLUPEIFORMES		<i>Lepadogaster condollei</i>	Lebour (1918, 1919, 1920)
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>L. lepadogaster</i>	Lebour (1918)
<i>B. tyrannus</i>	Kjelson et al. 1975)	<i>Micropogonias undulatus</i>	Govoni et al. (1983)
<i>Clupea harengus</i>	Bowers and Williamson (1951)	<i>Myoxocephalus undulatus</i>	Laroche (1982)
<i>Clupea harengus</i>	Gamble et al. (1981)	<i>M. octodecemspinosus</i>	Laroche (1982)
<i>Clupea harengus</i>	Lebour (1918, 1920, 1921)	<i>M. scorpius</i>	Laroche (1982)
<i>Clupea harengus</i>	Ogilvie (1927)	<i>Trachurus symmetricus</i>	Arthur (1976)
<i>Clupea harengus</i>	Sherman and Honey (1971)	<i>Triglops murrayi</i>	Laroche (1982)
<i>Sardina pilchardus</i>	Lebour (1921)	PLEURONECTIFORMES	
<i>Sprattus sprattus</i>	Lebour (1921)	<i>Limanda limanda</i>	Lebour (1920)
PERCIFORMES		<i>Microchirus variegatus</i>	Lebour (1918)
<i>Agonus cataphractus</i>	Lebour (1920)	<i>Pseudopleuronectes americanus</i>	Pearcy (1962)
<i>Callionymus lyra</i>	Lebour (1919)	<i>Solea solea</i>	Lebour (1918)
<i>Ctenolabrus rupestris</i>	Lebour (1920)	GADIFORMES	
<i>Diplecogaster bimaculatus</i>	Lebour (1919)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Gobius niger</i>	Lebour (1919)	<i>Merlangius merlangus</i>	Lebour (1920)
<i>Gobiusculus flavescens</i>	Lebour (1919, 1920)	<i>Pollachius pollachius</i>	Lebour (1919, 1920)
<i>Labrus bergylta</i>	Lebour (1919, 1920)	<i>Trisopterus luscus</i>	Lebour (1920)
<i>L. bimaculatus</i>	Lebour (1920)		
<i>Lagodon rhomboides</i>	Kjelson et al. (1975)		
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)		
<i>Leiostomus xanthurus</i>	Kjelson et al. (1975)		

Appendix Table 14.—Species of fish whose larvae have been reported to eat tintinnids.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Anchoa mitchelli</i>	Detwyler and Houde (1970)	<i>Limanda limanda</i>	Last (1978a)
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Limanda limanda</i>	Lebour (1918)
<i>Clupea harengus</i>	Bainbridge and Forsyth (1971)	<i>Microchirus variegatus</i>	Lebour (1918)
<i>Clupea harengus</i>	Lebour (1920, 1921)	<i>Phrynorhombus norvegicus</i>	Lebour (1918)
<i>Clupea harengus</i>	Sherman and Honey (1971)	<i>Platichthys flesus</i>	Last (1978a)
<i>Engraulis mordax</i>	Arthur (1976)	<i>Pseudopleuronectes</i>	
<i>E. ringens</i>	Mendiola (1974)	<i>americanus</i>	Pearcy (1962)
<i>Sardinops sagax</i>	Arthur (1976)	<b>GADIFORMES</b>	
<i>Sprattus sprattus</i>	Lebour (1921)	<i>Gadus morhua</i>	Last (1978b)
<b>PERCIFORMES</b>		<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)	<i>Merlangius merlangus</i>	Last (1978b)
<i>Micropogonias undulatus</i>	Govoni et al. (1983)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Trachurus symmetricus</i>	Arthur (1976)	<i>Trisopterus luscus</i>	Last (1978b)

Appendix Table 15.—Species of fish whose larvae have been reported to eat species of *Evadne*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Clupea harengus</i>	Lebour (1918, 1921)	<i>Scophthalmus maximus</i>	Last (1979)
<i>Clupea harengus</i>	White (1980)	<i>Solea solea</i>	Lebour (1918)
<i>Engraulis anchoita</i>	Ciechowski (1967)	<b>GADIFORMES</b>	
<b>PERCIFORMES</b>		<i>Gadus morhua</i>	Sysoeva and Degtereva (1965)
<i>Auxis</i> sp.	Uotani et al. (1981)	<i>Melanogrammus aeglefinus</i>	Marak (1960)
<i>Katsuwonus pelamis</i>	Uotani et al. (1981)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Lepadogaster condollei</i>	Lebour (1920)		
<i>Scomber scomber</i>	Lebour (1920)		
<i>Thunnus alalunga</i>	Uotani et al. (1981)		
<i>T. albacares</i>	Uotani et al. (1981)		
<i>T. maccoyii</i>	Uotani et al. (1981)		
<i>T. obesus</i>	Uotani et al. (1981)		
<i>Trachinus vipera</i>	Lebour (1920)		

Appendix Table 16.—Species of fish whose larvae have been reported to eat species of *Podon*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Clupea harengus</i>	Ogilvie (1927)	<i>Limanda limanda</i>	Lebour (1918, 1920)
<i>Engraulis anchoita</i>	Ciechowski (1967)	<i>Microchirus variegatus</i>	Lebour (1918)
<b>PERCIFORMES</b>		<i>Phrynorhombus norvegicus</i>	Lebour (1918, 1920)
<i>Ammodytes tobianus</i>	Lebour (1919)	<i>P. regius</i>	Lebour (1918)
<i>Blennius gattorugine</i>	Lebour (1918, 1919)	<i>Psetta maxima</i>	Lebour (1920)
<i>Callionymus lyra</i>	Lebour (1918, 1920)	<i>Scophthalmus maximus</i>	Last (1979)
<i>Coryphoblennius galerita</i>	Lebour (1919)	<i>S. rhombus</i>	Lebour (1918)
<i>Crystallogobius nilssonii</i>	Lebour (1918)	<b>GASIFORMES</b>	
<i>Ctenolabrus rupestris</i>	Lebour (1920)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Diplecogaster bimaculatus</i>	Lebour (1920)	<i>Merlangius merlangus</i>	Lebour (1920)
<i>Eutrigla gurnardus</i>	Lebour (1918, 1920)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Gobiusculus flavescens</i>	Lebour (1919)	<i>Molva molva</i>	Lebour (1920)
<i>Labrus bergylta</i>	Lebour (1918, 1919, 1920)	<i>Pollachius pollachius</i>	Lebour (1920)
<i>L. bimaculatus</i>	Lebour (1920)	<i>Trisopterus luscus</i>	Lebour (1920)
<i>Lepadogaster condollei</i>	Lebour (1919, 1920)	<i>T. minutus</i>	Lebour (1918, 1920)
<i>Scomber scomber</i>	Lebour (1920)		
<i>Trachinus vipera</i>	Lebour (1920)		
<i>Trachurus trachurus</i>	Lebour (1920)		



Appendix Table 17.—Species of fish whose larvae have been reported to eat barnacle nauplii.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<i>Leiostomus xanthurus</i>	Kjelson et al. (1975)
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Micropogonias undulatus</i>	Govoni et al. (1983)
<i>B. tyrannus</i>	Kjelson et al. (1975)	<i>Myoxocephalus aeneus</i>	Laroche (1982)
<i>Clupea harengus</i>	Bjørke (1978)	<i>M. octodecemspinus</i>	Laroche (1982)
<i>Clupea harengus</i>	Lebour (1918, 1920, 1921)	<i>M. scorpius</i>	Laroche (1982)
<i>Clupea harengus</i>	Ogilvie (1927)	<i>Pomatoschistus microps</i>	Lebour (1920)
<i>Clupea harengus</i>	Sherman and Honey (1971)	<i>Taurulus bubalis</i>	Lebour (1918, 1919, 1920)
<i>Harengula pensacolatae</i>	Detwyler and Houde (1970)	<i>Triglops murrayi</i>	Laroche (1982)
<b>PERCIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Agonus cataphractus</i>	Lebour (1919, 1920)	<i>Psetta maxima</i>	Lebour (1918)
<i>Callionymus lyra</i>	Lebour (1918)	<i>Solea solea</i>	Lebour (1918)
<i>Diplecogaster bimaculatus</i>	Lebour (1919, 1920)	<b>GADIFORMES</b>	
<i>Gobiusculus flavescens</i>	Lebour (1919)	<i>Merlangius merlangus</i>	Lebour (1919, 1920)
<i>Labrus bergylta</i>	Lebour (1919, 1920)		
<i>Lagodon rhomboides</i>	Kjelson et al. (1975)		

Appendix Table 18.—Species of fish whose larvae have been reported to eat gastropod larvae.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Anchoa mitchelli</i>	Detwyler and Houde (1970)	<i>Limanda limanda</i>	Lebour (1920)
<i>Clupea harengus</i>	Bowers and Williamson (1951)	<i>Pleuronectes platessa</i>	Shelbourne (1953)
<i>Clupea harengus</i>	Gamble et al. (1981)	<i>Scophthalmus maximus</i>	Last (1979)
<i>Clupea harengus</i>	Lebour (1918, 1920, 1921)	<i>Solea solea</i>	Last (1978a)
<i>Clupea harengus</i>	Ogilvie (1927)	<b>GADIFORMES</b>	
<i>Engraulis mordax</i>	Lasker et al. (1970)	<i>Ciliata mustela</i>	Lebour (1920)
<i>Sprattus sprattus</i>	Lebour (1919, 1921)	<i>Melanogrammus aeglefinus</i>	Marak (1960)
<b>PERCIFORMES</b>		<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Ammodytes tobianus</i>	Lebour (1920)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Diplecogaster bimaculatus</i>	Lebour (1919)	<i>Pollachius pollachius</i>	Lebour (1920)
<i>Gobiusculus flavescens</i>	Lebour (1919, 1920)		
<i>Labrus bergylta</i>	Lebour (1920)		
<i>Lepadogaster lepadogaster</i>	Lebour (1919)		
<i>Pomatoschistus microps</i>	Lebour (1919)		
<i>Scomber scomber</i>	Lebour (1918)		
<i>Taurulus bubalis</i>	Lebour (1918, 1919)		
<i>Trachurus trachurus</i>	Lebour (1920)		

Appendix Table 19.—Species of fish whose larvae have been reported to eat species of *Limacina*.

Fish species	Reference	Fish species	Reference
<b>CLUPEIFORMES</b>		<b>GADIFORMES</b>	
<i>Brevoortia patronus</i>	Govoni et al. (1983)	<i>Melanogrammus aeglefinus</i>	Ogilvie (1938)
<i>Clupea harengus</i>	White (1977)	<i>Micromesistius poutassou</i>	Conway (1980)
<i>Engraulis mordax</i>	Arthur (1976)		
<i>Sardinops sagax</i>	Arthur (1976)		
<b>PERCIFORMES</b>			
<i>Leiostomus xanthurus</i>	Govoni et al. (1983)		
<i>Micropogonias undulatus</i>	Govoni et al. (1983)		

Appendix Table 20.—Species of fish whose larvae have been reported to eat appendicularians.

Fish species	Reference	Fish species	Reference
<b>PERCIFORMES</b>		<b>PLEURONECTIFORMES</b>	
<i>Ammodytes marinus</i>	Ryland (1964)	<i>Limanda limanda</i>	Last (1978a)
<i>Ammodytes marinus</i>	Wyatt (1974)	<i>Platichthys flesus</i>	Last (1978a)
<i>Auxis</i> sp.	Uotani et al. (1981)	<i>Pleuronectes platessa</i>	Last (1978a)
<i>Katsuwonus pelamis</i>	Uotani et al. (1981)	<i>Pleuronectes platessa</i>	Ryland (1964)
<i>Thunnus alalunga</i>	Uotani et al. (1981)	<i>Pleuronectes platessa</i>	Shelbourne (1953, 1957, 1962)
<i>T. albacares</i>	Uotani et al. (1981)	<i>Pleuronectes platessa</i>	Wyatt (1974)
<i>T. maccoyii</i>	Uotani et al. (1981)	<i>Scophthalmus maximus</i>	Last (1979)
<i>T. obesus</i>	Uotani et al. (1981)		
		<b>GADIFORMES</b>	
		<i>Micromesistius poutassou</i>	Conway (1980)