Biological Report 82 (11.69)
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TR EL-82-4

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)

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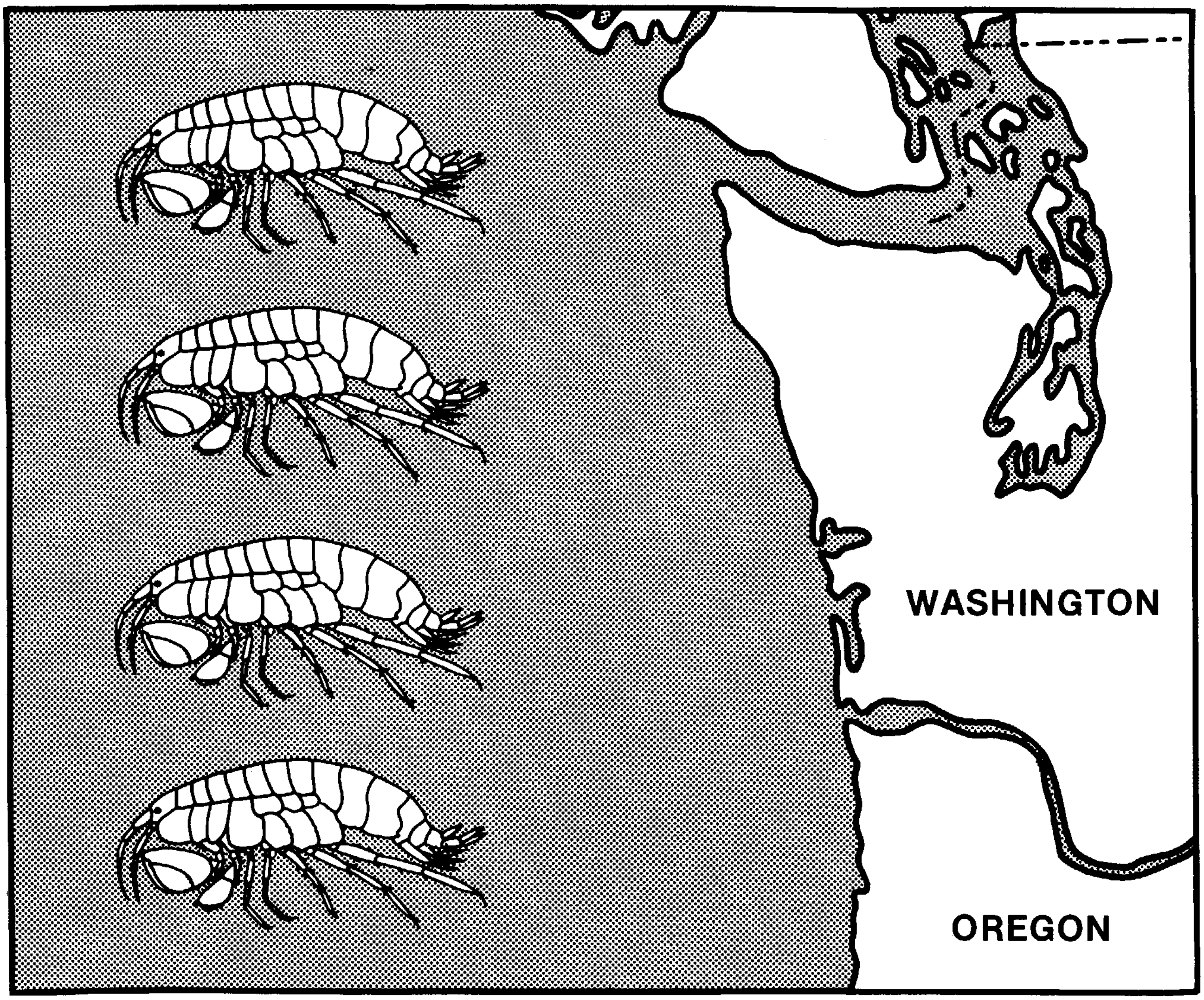

Coastal Ecology Group
Fish and Wildlife Service
Waterways Experiment Station
U.S. Department of the Interior
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)

AMPHIPODS

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Performed for
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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

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CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees	0.5556(°F - 32)	Celsius degrees

CONTENTS

ACKNOWLEDGMENTS

We gratefully acknowledge the reviews by Rick Albright, School of Fisheries, University of Washington, Seattle, and Craig P. Staude, Friday Harbor Laboratories, University of Washington, Seattle.

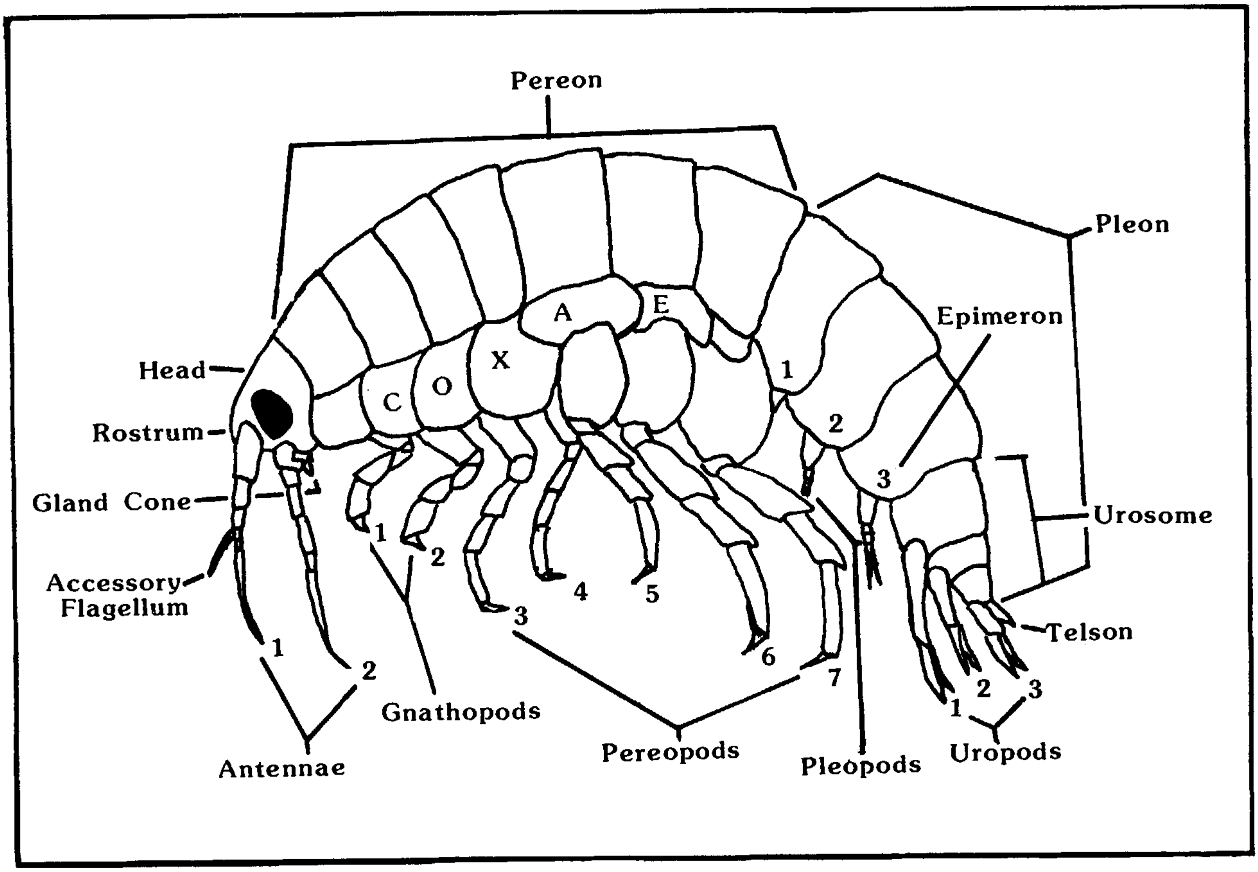

Figure 1. A gammaridean amphipod (from Staude et al. 1977).

AMPHIPODS

NOMENCLATURE/TAXONOMY/RANGE

Scientific name (Figure 1)	Amphipoda
Preferred common name	Amphipods
Class	Crustacea
Subclass	Malacostraca
Order	Amphipoda
Suborders	Gammaridea, Hyperiidea, Caprellidea, Ingolfiellidea (Figure 2).

Geographic range: This report will focus largely on the suborders Gammaridea, Caprellidea, and Hyperiidea because of their importance in coastal areas of the northeast Pacific Ocean (Figure 3). Gammaridea are the most abundant and diverse of the amphipods. Although primarily marine, they are also found in freshwater and certain moist terrestrial habitats (Reish and Barnard 1979). Marine Gammaridea are ubiquitously distributed. They are found in all regions, in all habitats, and at most depths. About 40% of the 80 gammaridean families are cosmopolitan in distribution; the remaining 60% are loosely associated with specific regions or zones (Barnard 1969; Bousefield 1978). Gammaridean distributions remain poorly known, but more recent studies (e.g., Barnard 1971) are

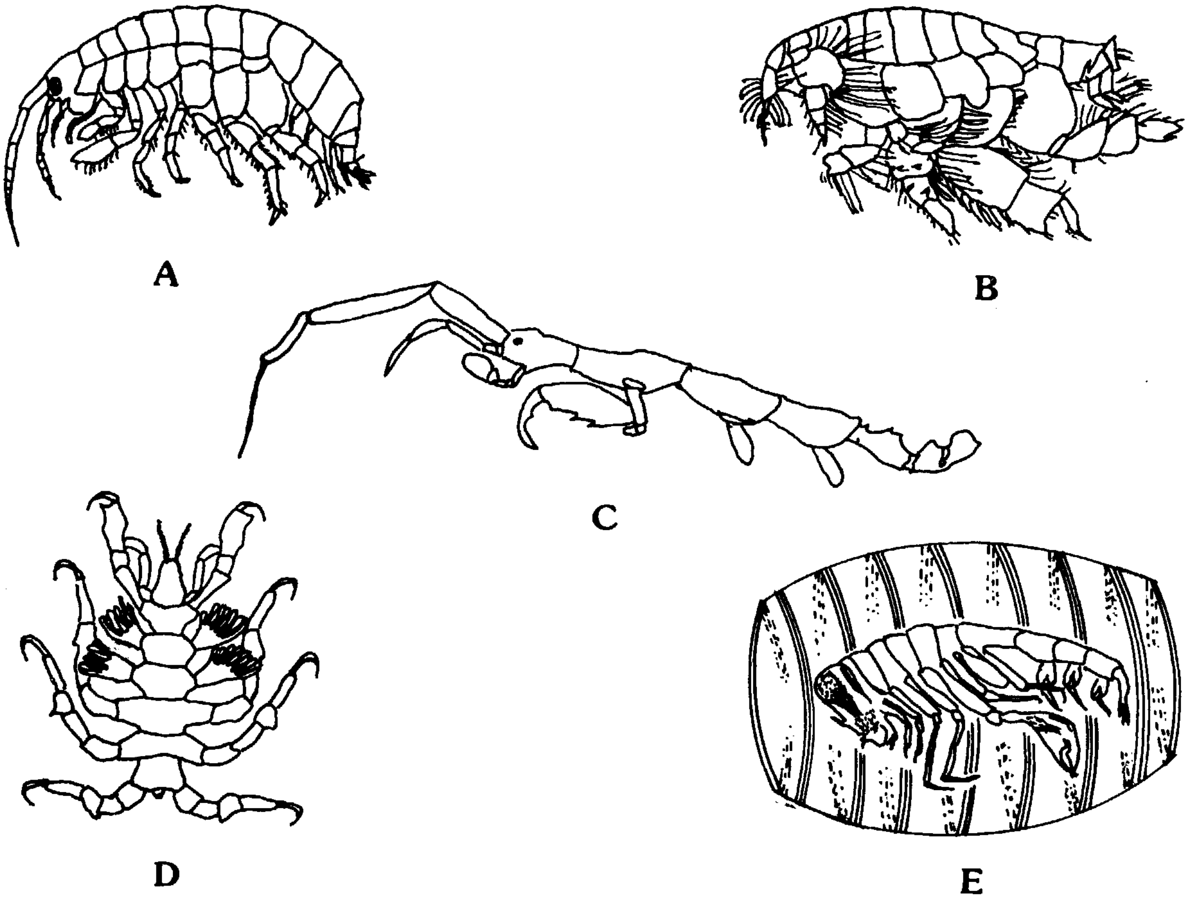

Figure 2. A, Elasmopus and B, Eohaustorius, both gammarid amphipods. C, Caprella ferrea, a caprellid amphipod. D, Neocyamus physeteris (female), a caprellid amphipod from sperm whale. E, Phronima sedentaria, a hyperiid amphipod that lives inside the tunic of urochordates. (A and B from Barnard 1975; C and D from McCain 1975; E from Barnes 1974. A-D reprinted with permission from the University of California Press; E reprinted with permission from Saunders College Publishing.)

finding more widespread distributions than were previously assumed. Off the Oregon Coast, 97 species of gammarids have been found from the surface to a depth of 2900 m (Barnard 1971), and 20 species divided among 11 families were in the upper 200 m (Pearcy 1972). About 200 gammarid species have been found in Washington waters (Staude et al. 1977). Some gammarid species dwell in subtidal or intertidal environments (Reish and Barnard 1979). The suborder Hyperiidea is entirely marine and pelagic; most members of the taxon live in the

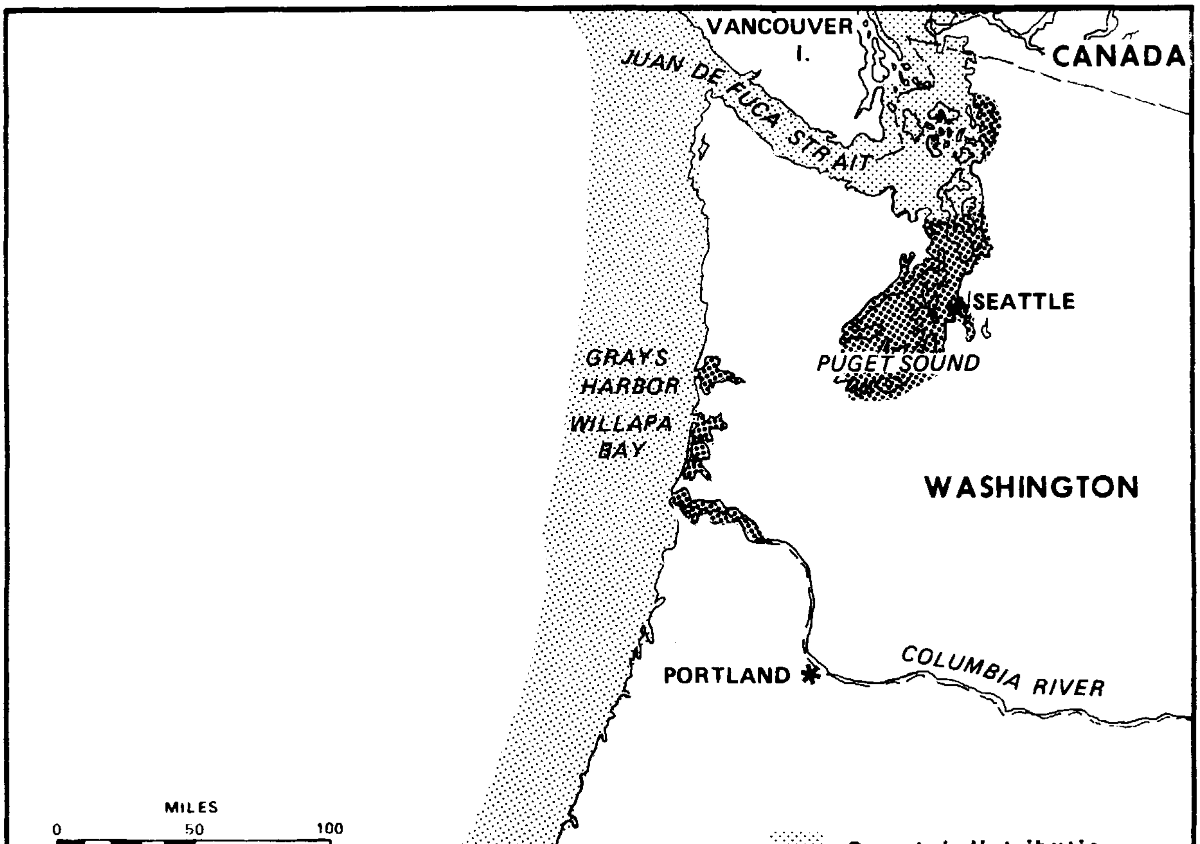

Figure 3. Distribution of the ubiquitous amphipod suborders Gammaridea and Hyperiidea in the coastal areas of the northeast Pacific Ocean.

bathyal zone, and some live in coastal waters (Bowman and Gruner 1973).

MORPHOLOGY/IDENTIFICATION AIDS

Animals of the order Amphipoda are distinguished by sessile, compound eyes, though some species are blind. A carapace is not present and the first, and sometimes the second, thoracic segments are fused with the head. A "shrimplike" appearance results from lateral body compression. Gammarids and hyperiids have three pairs of pleopods (swimmerets); two or three pairs of uropods on the pleon (abdomen); at least eight pairs of thoracopods, counting the maxilliped; usually seven major leg pairs, called pereopods; and five or more pairs of gills. Males and females often can be distinguished morphologically. The head has five fused segments, two pairs each of antennae and maxillae, a heavily chitinized mandible, and a limblike maxilliped. There are seven freely articulated somites on the thorax (pereon). Coxal platelike lateral extensions of the thoracic pereon are developed from the first segment of each leg. Branchiae (gills) are fleshy and platelike and are attached medial to the coxae, 2-6 on each side. The abdominal region consists of three articulating segments on both anterior pleon and posterior urosome; the urosome has a terminal telson.

The following key (adapted from Barnes 1974; Kozloff 1974) is presented as an aid to separate the suborders of amphipods:

1a. Pereon with seven apparent segments, all having well-developed appendages. Abdomen not vestigial. Body neither slender nor resembling that of a praying mantis. 2

1b. Pereon with six apparent segments, some may have vestigial appendages; abdomen vestigial; head fused with second thoracic segment. Body slender and resembling that of a praying mantis (except for whale lice). Marine. Includes skeleton shrimp . . . Suborder Caprellidea.

2a. Eyes generally large, occupying most of head; coxae of pereopods small, often fused with the body, maxillipeds without palp; last two abdominal segments fused; body more or less transparent. Marine, and usually planktonic or associated with jellyfish or in tunics of dead salps . . . . .Suborder Hyperiidea.

2b. Eyes usually present and conspicuous, but not large enough to cover most of the head; coxae of pereopods well developed, usually expanded. Marine, freshwater, and terrestrial . . . Suborder Gammaridea.

2c. Body elongate; coxae small; abdominal segments distinct; all but fourth and fifth pairs of abdominal appendages vestigial. Marine, interstitial. Rare. . . . Suborder Ingolfiellidea.

There currently exists no concise guide to amphipod species in the northwest Pacific. Publications of the National Museum of Canada, such as that by Conlan and Bousfield (1982), will eventually culminate in a comprehensive regional handbook on marine gammarideans. Contributions by Barnard (1975) and Staude et al. (1977) may be useful for identifying Gammaridea in restricted intertidal regions; the work of Bousfield (1978) described freshwater Gammaridea. Kozloff (1974) provided keys to the Caprellidea. Hyperiids can be identified to genus by using the descriptions published by Bowman and Gruner (1973).

REASON FOR INCLUSION IN SERIES

Hyperiid amphipods are the third most abundant group of coastal marine crustacean zooplankton, following

Copepoda and Euphausidea (Bowman and Gruner 1973). The benthic amphipods, especially Gammaridea, are an invaluable food source for many economically important fish and invertebrate species. Their limited mobility suggests that their distribution and abundance can be used as an indicator of environmental quality (Albright 1982). Omnivorous, opportunistic feeders such as lysianassids (a gammaridean family) recycle detritus and may help avert pollution by scavenging carcasses of larger animals following mass mortalities (Reish and Barnard 1979).

LIFE HISTORY

Female Amphipoda spawn via an amplexus (mating embrace) with males which lasts for hours or days. In swimming species the female swims with the male on top, or both swim on their sides. Following ecdysis (molting) and mating, eggs are laid through two ventral pores in the female's sixth thoracic sternite. Eggs can number from 1 to 200 or more. Thin, tube-dwelling gammarids have the fewest eggs, which tend to be large or contain large amounts of yolk. Because of the large size of the eggs, only one can be carried by some young females, while fully mature females carry three or four. Eggs hatch directly into juveniles resembling adults. In gammarids, one-quarter to one-half of the eggs may die before hatching. Juveniles are generally held in the brood pouch for a few hours to a few days after hatching before they are released (Barnard 1969; Reish and Barnard 1979).

Chang and Parsons (1975) found that the common inshore gammarid Anisogammarus pugettensis breeds year round in the Pacific Northwest, in contrast to beach and some intertidal amphipods of the cooler North Atlantic. Those species either have one brood per year or cease their reproductive activity during the coldest winter months. Females lay eggs during each of the last five or six molting stages, or at every other stage (Barnard 1969).

GROWTH CHARACTERISTICS

Growth is initially rapid in Gammaridea; molting initiates within several days of hatching and continues after maturity, slowing to every 20 to 30 days in the later stages of development. The average instar (stage of development between successive molts) lasts 15 days. Gammarids go through at least 12 instars; thus, the maximum lifespan estimates are a little more than 6 months, although some polar species are known to live 5 or 6 years (Reish and Barnard 1979).

Amphipod growth rates and lengths vary considerably. Adult amphipods range in size from less than 1 cm to about 28 cm, the largest being an undescribed lysianassid that was photographed in the abyssal Pacific Ocean (Schmidt 1968). Maximum growth rates of A. pugettensis, mentioned above, were 4.1% per week at 10 °C, increasing more than threefold to 14.3% per week at 20 °C (Figure 4), with higher efficiency at 20 °C. Growth relative to food intake in large (10 mg) individuals of this species was 47% to 72% when fed Enteromorpha (Chang and Parsons 1975).

POPULATION DYNAMICS AND IMPORTANCE TO FISHERIES

Amphipods are the main food item of many fish species, as well as other aquatic animals (Figure 5). Some pelagic species sometimes comprise the bulk of the diet of herring, mackerel, and Biscayan tunny (Schmitt 1968). Gammarids, on the basis of the Index of Relative Importance (IRI), were the most important food species for nearshore fishes in the Strait of Juan de Fuca (comprising more than half of

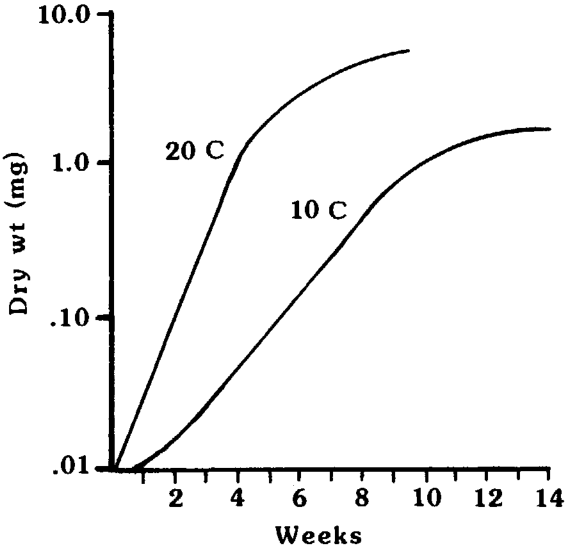

Figure 4. Growth of *Anisogammarus pugettensis* fed *Enteromorpha intestinalis* at 10 and 20 °C. (Reprinted with permission from the *Journal of the Fisheries Research Board of Canada*, from Chang and Parsons 1975).

the total IRI spectrum for 38% of the 55 fish species studied) and were the most important food item to tidepool fishes (Cross et al. 1978). For the most part, the gammarids were epibenthic rather than infaunal or pelagic. Cross et al. (1978) suggested that since hyperiid populations on which neritic fishes feed are naturally patchy, small localized perturbations are likely to create more patchiness. If adjacent areas remain unaffected, the neritic fish populations may not be adversely affected. However, sublittoral fishes, especially juvenile fishes, are more dependent on epibenthic prey, and thus more likely to be affected by perturbation, although the amphipod supply is often replenished by tidal action. Because of their relative isolation, tidepool fishes are most heavily affected by perturbation (Cross et al. 1978).

Mason (1974) hypothesized that delayed seaward migrations of juvenile chum salmon (*Oncorhynchus keta*) and coho salmon (*Oncorhynchus kisutch*) may be attributable in part to the abundance of food organisms in rivers and estuaries. Abundant populations of gammarids in the upper estuary of Hyman Creek, British Columbia, constituted the main diet of the fry of these two salmon species. They also constituted the majority of the diet of chum fry at six nearby estuaries at low tide in the spring.

Corophium salmonis, a tube-dwelling gammarid, is an abundant and preferred prey organism of chum salmon in the Skagit River salt marsh in Washington State (Congleton and Smith 1976). Though little is known of the seasonal abundances of *C. salmonis*, Albright (1982) found peak densities of the species in tide flats of Grays Harbor, Washington, in July and August. In the inner half of the bay they were the dominant organism on mud and sandy mud bottoms. Densities as high as 57,000/m^2 have been observed (Albright and Rammer 1976). From April through September production was 3.6-10.7 g/m^2, and turnover (production/mean biomass) was 7.2 to 8.6 g/m^2. In Grays Harbor, *C. salmonis* is an important prey item for dunlin (*Calidris alpina*), English sole (*Parophyrys vetulus*), and starry flounder (*Platichthys stellatus*) according to Smith and Mudd (1976) and for other fish species, as well as shrimp (*Crangon* spp.) and Dungeness crab (*Cancer magister*) (Albright 1982). Smith (1980) reported similarly high *C. salmonis* densities and predation on this amphipod by various species in other northwest estuaries.

Numerically, amphipods are the major component of the fauna of harbor pilings in California. Most are introduced species that have had little effect on indigenous amphipods in nearby areas (Barnard 1961; Reish 1964). Negligible economic loss due to fouling has resulted (Reish and Barnard 1979). In heavily polluted

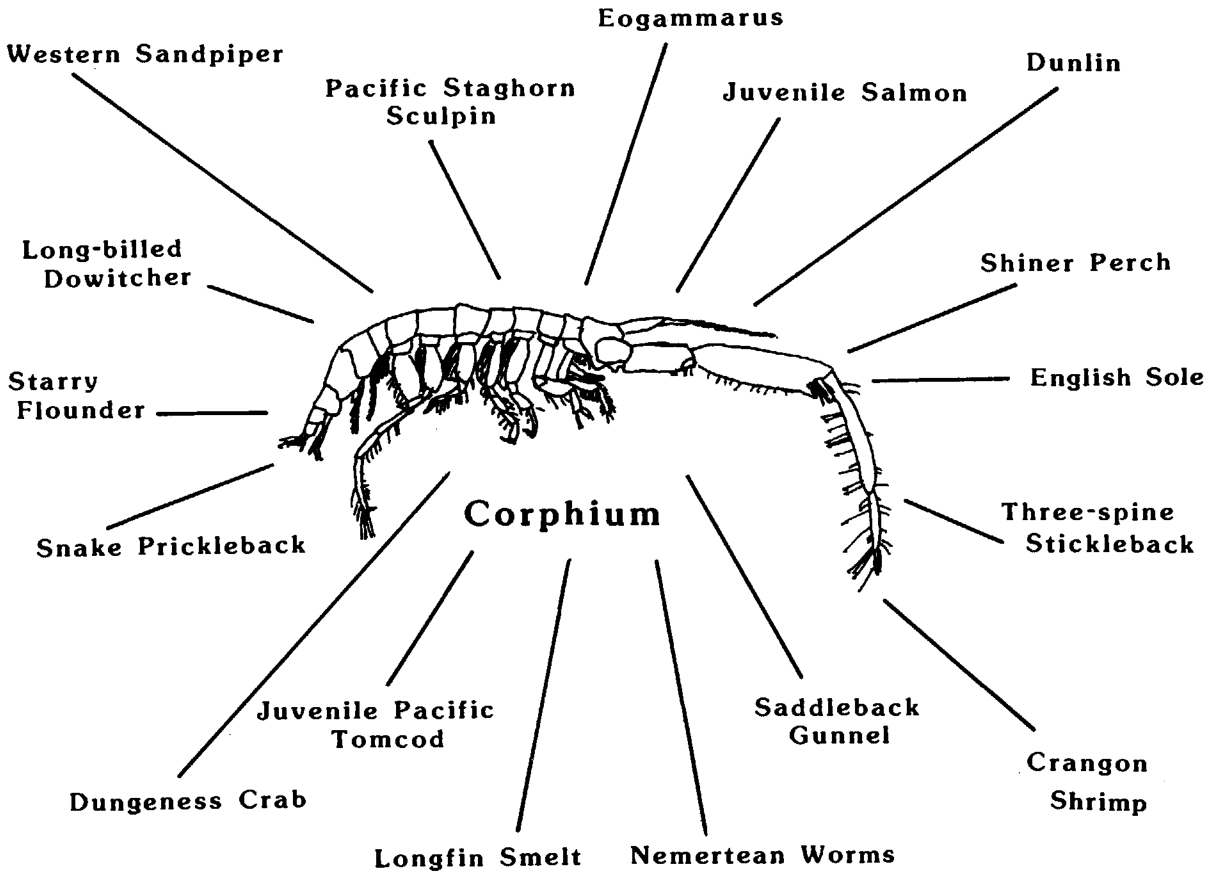

Figure 5. Fish and invertebrate predators of the amphipod Corophium salmonis (from Albright 1982).

sections of harbors, amphipods are reportedly absent both in the benthos and on pilings (Reish 1959).

Of the pelagic organisms in the upper 200 m off the Oregon coast, hyperiids comprise more than 10% of organisms by number; their abundance is known to vary seasonally (Van Arsdale 1967, cited by Pearcy 1972).

Two gammarid species have been examined for their potential as food in fish culture. Mass culture of Anisogammarus pugettensis was proposed by Chang and Parsons (1975) as an alternative to brine shrimp culture for young salmon; A. pugettensis can tolerate wide ranges of temperatures and salinities and thrives on a variety of plant and animal material. It also scavenges dead fishes and uneaten fish food in ponds. However, its growth is slower than that of brine shrimp. Gammarus lacustris, found in shallow prairie lakes of the Hudson Bay drainage, meets dietary requirements for rainbow trout (Salmo gairdneri) 5 cm or greater, is easily captured, and can be harvested at a rate of 1,000 kg per ha per year. For most food ingredients it is comparable to or better than commercial feeds, and it improves body coloration and hence marketability of trout (Mathias et al. 1982).

ECOLOGICAL ROLE

Amphipods are considered the most efficient scavengers of sea bottoms and shores, probably clearing up and recycling more organic shore debris than any other animal (Schmitt 1968). Griffiths and Stenton-Dozey (1981) described the importance of the gammarid *Talorchestia capensis* in consuming beached kelp in South Africa. This species and dipteran larvae consume some 60% to 80% of beached kelp within 2 weeks, and the gammarid is thought to make a significant contribution (through feces) to organic enrichment of the inshore marine system.

Caine (1980), in an ecological comparison of two littoral species of caprellid amphipods in Washington State, indicated that each species has a different effect on its community. *Deutella californica* is a predator, but its removal did not alter community structure, even though it displays a preference for the epibiotic community of *Obelia dichotoma*. In contrast, *Caprella laeviuscula* is a periphyton scraper that has an enormous impact on the periphyton on *Zostera marina*, and thus increases available light for the seagrass, and permits its growth in areas where it would have otherwise been excluded. Observations on interspecific aggressive behavior indicate that *C. laeviuscula* is dominant over other caprellids in protected habitats. Predatory caprellids did not appear to occur together where they would compete directly for food, while filter-feeding caprellids do compete to some extent for food (Caine 1977).

Reish and Barnard (1979) categorized gammarids and hyperiids by habitat. Nestlers include beach-hoppers of the gammarid family Talitridae, commonly found on sandy intertidal areas. High numbers occur under moisture-maintaining algal wrack, as discussed above. These species must be transitory, the authors speculated, because of frequent changes in tide and wrack accumulations. Species of six or seven gammarid families (e.g., *Ampelisca* sp. and *Photis* sp.) construct tubes or cradles on soft or hard substrata, according to Barnard (1969). *Corophium* sp., common in estuaries where silting is heavy, forms masses of heavy tubes and creates currents with its abdominal appendages. The currents are strained by fringes of fine hairs on the appendages forward of the abdomen; then whatever is collected is scraped into the mouth (Kozloff 1973). Other species inhabit dwellings of other organisms. Many species are burrowers, especially in the gammarid families Haustoriidae, Oedicerotidae, and Phoxcephalidae. Elongated setae on the distal articles of the posterior pereopods are an adaptation for burrowing (Reish and Barnard 1979).

A number of Gammaridea live on sedentary invertebrates such as corals, sponges, tunicates, anemones, and polychaetes. Their relationships with the hosts are not well understood (Reish and Barnard 1979).

Hyperiidea are primarily nektonic. They have well-developed swimming devices or buoyancy control, or are found in association with medusae or salps (Reish and Barnard 1979). *Phronima* sp., sometimes collected in plankton tows or along docks in the San Juan Islands, is found in empty salp tests (Kozloff 1974). Hyperiids may feed on the very organisms that host them, but may also use them as a base from which to forage, or they may feed on food captured by the host (Bowman et al. 1963). Their feeding habits are poorly understood. In one laboratory study of *Lestrigonus* sp. and *Bougisia* sp., food was shared with the host, *Leptomedusa* sp., when food supply was adequate, but when it was not, the amphipods fed on host tissue (Bowman and Gruner 1972). *Parathemisto* sp., a free-living hyperiid, preys on other plankters (Bowman 1960).

A few nektonic gammarids are found in neritic waters. These are either predators or are mating or dispersal phases of benthic gammarids (Reish and Barnard 1979).

Chelura terebrans, a wood-borer found in California, is the best known amphipod pest. It enlarges holes in wood made by the isopod Limnoria sp. (Reish and Barnard 1979).

The swimming capability of epibenthic gammarids may reduce their susceptibility to predation. Feller and Kaczynski (1975) suggest that harpacticoid copepods were preferred over amphipods by juvenile chum salmon in Puget Sound during the spring because they are relatively easy to capture. Simenstad (1976) noted the same predatory habits for juvenile pink and chum salmon in Hood Canal, Washington, and found that juvenile salmon, in addition to preferring the less numerous and smaller harpactacoid copepods, also consumed gammarid eggs.

Anisogammarus conferviculus is believed to defend or "buffer" its populations against predation by migrating fishes, such as juvenile chum salmon, by ecological adaptations. These adaptations decrease the foraging efficiency of the predator and include association with refuges in vegetation, clumping in refuges, association with structurally complex habitats and distributions related to riverflow and tides (Levings and Levy 1976). In Grays Harbor, Washington, however, mature male C. salmonis are subject to heavy predation beginning in April, when they wander over tideflats in search of females (Albright 1982).

Hyperiid swimming varies from feeble movement of appendages in Cystisoma sp. to rapid swimming in Paraprone sp. which has strong pleonal musculature (Bowman and Gruner 1973). Caprellids, attaching with posterior legs, feed by grasping food with their free anterior legs and antennae. Locomotion is accomplished with a loop-like movement in which the front legs attach while the rear ones release and reattach (Kozloff 1973).

In addition to being prey for many fish and invertebrate species, some pelagic amphipods comprise part of the crustacean diet of whales. Most of the grey whale diet on the west coast consists of six species of benthic amphipods (Matthews 1978). British gulls are also known to consume benthic amphipods (Schmitt 1968).

Locomotion in gammarids is largely by swimming; they are poorly balanced for walking. Even burrowers are strong swimmers. Small coupling hooks join pleopods, facilitating coordinated paddling motions. Some softbottom gammarids have elongated pereopods spread out like a spider's legs to prevent sinking into the mud. The body hangs upside down, lowering the center of gravity. Sediment burrowers possess strong and densely packed spines on their pereopods (Barnard 1969).

Caprellids, the suborder which includes skeleton shrimp, are largely intertidal and shallow subtidal. Their preference of substrate in the Pacific Northwest is not specific, but they do need to cling to something. Thus, they are found on algae, seagrasses, sponges, hydroids, and bryozoans, but not on bare sand or mud bottoms. Caprellids feed on diatoms, small invertebrates, and possibly detritus, and are prey for many fishes (including cod, blennies, and skates) and also for shrimp (McCain 1975). Whale parasites of the genus Cyamus are also in the caprellid suborder. This group includes about 18 host-specific species. They lack a free-swimming stage; they leave the parental brood pouch and dig into the host with hooked dactyls (Schmitt 1968).

ENVIRONMENTAL REQUIREMENTS

Dissolved Oxygen

Pelagic gammarid and hyperiid amphipods have been collected from a scattering layer in deep, poorly oxygenated waters off southeastern Vancouver Island, British Columbia (Waldichuck and Bousfield 1962). *Anisogammarus* sp. and *Allorchestes* sp., both common inshore gammarid amphipod genera, were found in low dissolved oxygen environments (as low as 0.04 ppm at 12 °C) near sulfite-rich paper pulp effluent. The former species was found in high numbers on the bottom (15 to 22 m) and the latter species, normally found in shallower waters, was observed near the surface, perhaps seeking more oxygenated water (Waldichuk and Bousfield 1962). Low oxygen tolerance in either species remains to be determined, but Chang and Parsons (1975) observed that *Anisogammarus pugettensis* survived for several hours at 20% saturation levels. They also determined a Q_{10} of 1.6, lower than those of other crustaceans for which it is around 2 (Q_{10} is the factor by which the metabolic rate increases after a 10° increase in temperature). They suggest that this is an adaptation for coping with rapidly changing intertidal temperatures. Caprellids are known to leave eelgrass beds "in droves" at night when dissolved oxygen levels in the beds drop below 2 ppm.

Tolerances to low dissolved oxygen levels vary greatly among species; many are very sensitive to low levels, especially species restricted to areas where dissolved oxygen does not historically vary greatly. Groups such as phoxocephalids (used as indicators of pollutant levels in sediment bioassays) appear much less tolerant to stressful conditions than many of the species discussed above (R. Albright, University of Washington; pers. comm.).

Salinity

Adult gammarids found in estuaries are fairly tolerant to a wide salinity range while many juveniles and embryos are not. Adult estuarine *Corophium volutator* survived in salinities of 2 to 59 ppt (McClusky 1967), but preferred a range of 10 to 30 ppt (McClusky 1970). Adult *C. triaenonyx* survived in a similarly wide range of salinities (Shyamasundari 1973), though juveniles could develop only at salinities of 7.5 to 37.5 ppt. For large numbers of individuals to survive and develop, 20 to 32.5 ppt were required (Shyamasundari 1976). *Anisogammarus pugettensis*, found naturally in 20 to 28 ppt salinities, cannot survive in freshwater but can survive at 11 ppt for at least 1 week (Chang and Parsons 1975). Some species, such as *Phoxocephalid* spp. or *Ampeliscad* spp., may have very narrow salinity tolerances. Other amphipods (e.g., *Gammarus* spp., *Hyalella* spp. and *Crangonyx* spp.) are found in freshwater.

Pollution and Dredging

Reish and Barnard (1979) observed that some amphipod species are more tolerant than others to organic pollution, but do not know what environmental factors cause the differences. It is known that some amphipods are sensitive to pollution in harbors. *Capitella* sp., a marine polychaete which is commonly used as a pollution indicator and which has a distribution that is often mutually exclusive to that of amphipods, is found in heavily polluted harbors. *Capitella* sp. is also found in unpolluted areas, such as deep sea bottoms off the coast of California, which are subject to freshwater inflow -- places where amphipods are notably absent (Reish and Barnard 1979).

The distribution of *Corophium salmonis* is influenced by sediment type and depth (it prefers shallow, muddy sand substrates) more than by salinity. Other species of Corophium exhibit greater production near sewer outfalls -- an increase which is presumably attributable to organic enrichment (Birklund 1977).

Behavioral changes in amphipods exposed to sublethal quantities of oil have been noted and suggest a sensitivity to fresh oil. Beach-hoppers are most likely to be affected by oil due to their occurrence in the high-tide wrack zone (Baker 1971), while species of Ampelisca show sensitivity in subtidal areas.

Dredging is likely to eliminate benthic amphipods, which live on or close to the substrate (Reish and Barnard 1979). However, McCaulley et al. (1977) suggest that in the event of dredging, adults are likely to move to nearby unaffected areas or juveniles may rapidly settle and repopulate the dredged areas (McCaulley et al. 1977). Crustaceans are generally very sensitive to pollution and, therefore, species dependent on them as food are indirectly affected by pollution.

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. They are prepared to assist in environmental impact assessment. Amphipods are ubiquitous in distribution. Hyperiidea are the third most abundant coastal marine crustacean zooplankton, following copepods and euphausids. Benthic Gammaridea are an invaluable food source for many economically important fish and invertebrate species. Lifestyles of the major amphipod groups are varied. On the basis of the Index of Relative Importance (IRI), they comprise more than half of the total IRI spectrum for 38 of 55 fish species in the Strait of Juan de Fuca. They are reported to be indicators of heavily polluted areas.

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