Mainland and Insular Assemblages of Benthic Decapod Crustaceans of Southern California

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INTRODUCTION

Although decapod crustaceans (crabs, hermit crabs, shrimp, and related groups) are among the largest and most familiar invertebrates of southern California, little is known of their distribution according to depth and substrate except in the littoral zone. Many species are known only from isolated collections taken over a span of decades.

During the extensive sampling program from 1975 through 1977 of the "Southern California Baseline Studies and Analysis: Benthic Macrofauna," 80 species of decapods were taken. Examination of the records of these species provided considerable information on their distribution. Recent cataloguing of specimens in the collections of the Allan Hancock Foundation has enabled comparison of these records with those of specimens taken since 1913 off southern California.

METHODS

During 1975-77, specimens were taken at 15 to 1,800 m by the R. V. *Velero IV* and *Thomas G. Thompson* by box cores, rock dredges, and beam trawls as part of the Southern California Baseline Studies and Analysis. During the preliminary direct data inspection, the species of decapods taken at each station were recorded on maps of the stations. The maps were examined to see if any obvious patterns could be detected. This cursory examination indicated that certain species occurred almost entirely either along the islands or near the mainland.

To facilitate comparison of the records, stations are called "mainland" if they are located along the mainland of southern California or in the basins between the mainland and the islands (Fig. 1). Island stations are those taken along the islands, Cortez Bank, or Tanner Bank.

Stations at 100 fathoms (185 m) or less are called shelf stations. The 185-m contour was chosen as the seaward limit of the shelf because it corresponds roughly to the maximum lowering of the sea level during Pleistocene glaciation (Shepard 1963). Stations between 100 and 500 fathoms (185 to 923 m) are labeled slope stations. Those stations between 500 and 1,000 fathoms (923 to 1,846 m) are entitled basin stations, and those deeper than 1,000 fathoms, bathyal stations. These deeper divisions correspond roughly to changes in the composition of the decapod fauna. Sampling stations from a range of depths are listed according to the greatest depth in order to determine the maximum lower limits of the species.

The substrate is recorded according to the description in the field log (*e.g.*, sand, mud, rocks, sand and shell). This descriptive designation (rather than grain size) was used in order to compare the stations sampled in 1975-77 with earlier stations at which no grain size analysis was made. Data on the grain size analysis and organic carbon content of the sediment at the 1975-77 stations will be published elsewhere.

A list was compiled of species taken at 10 or more stations during the sampling program of 1975-77. Additional records of these species were taken from the literature and from records of materials in the collections of the Allan Hancock Foundation. These materials include specimens taken by baited traps, trawls, grabs, dredges, box cores, and by hand. The specimens were from more than 1,000 stations located off San Miguel, Santa Rosa, Santa Cruz, Anacapa,

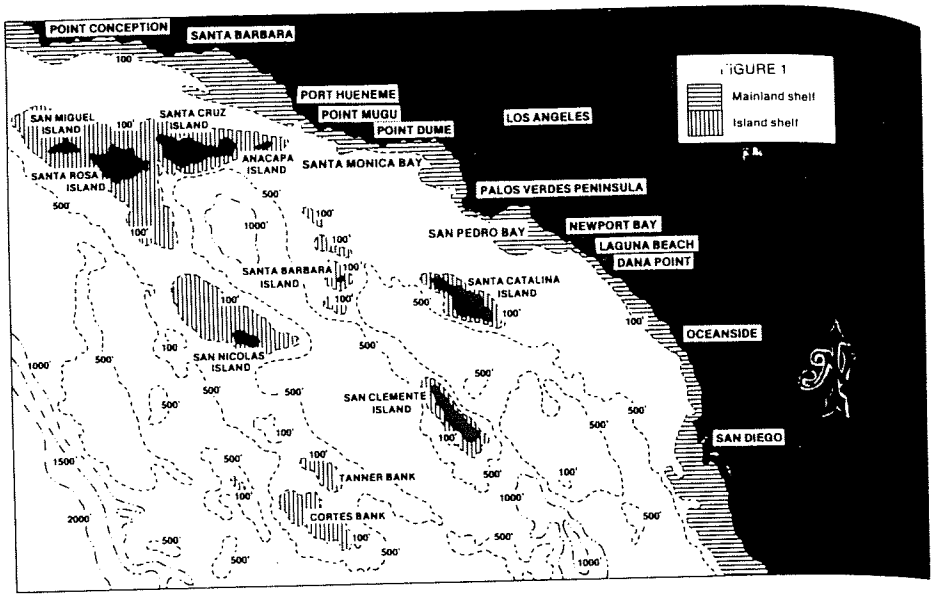

FIGURE 1. *Depth contours and locations of island and mainland shelves off southern California.*

Santa Barbara, San Nicolas, Santa Catalina, and San Clemente Islands, Tanner and Cortez Banks, Point Conception, Santa Barbara, Port Hueneme to Point Mugu, Point Dume, Santa Monica and San Pedro Bays, the Palos Verdes peninsula, Newport to Dana Point, Oceanside, and San Diego (Fig. 1). Collections were made in 1913-26 by the R. V. *Anton Dohrn*, in 1932-42 by the R. V. *Velero III*, in 1948-54 by the R. V. *Velero IV*, since 1970 by researchers at King Harbor and on sandy beaches in southern California, and by private collectors since 1913. Similar information was compiled for the crabs *Cancer anthonyi* and *Cancer gracilis*, the ghost shrimps *Callianassa* spp., and the hermit crab *Orthopagurus minimus*, for which extensive substrate data from previous surveys were available. Data also were compiled for species taken at 546 fathoms (1,000 m) or deeper during 1975-77, although none of these species occurred at as many as 10 stations.

The large variation in the quantity and quality of data for the stations, the gaps in time between periods of sampling, the incomplete lists of species for older stations, and the wide range of techniques used in sampling make numerical analyses of the data by standard statistical methods impossible. Species inhabiting the continental shelves were classified as mainland or insular if twice as many specimens or station occurrences were found in one area as in the other. Because stations from deeper areas were sampled more frequently off the islands, designation of the species at these depths as mainland or insular was not possible. The classification of species by depth is based on the range of the majority of stations at which each species was found (except in the case of *Pandalus platyceros*, which occurs at all depths).

The ranges of the species are recorded as follows: southern (S), reaching their northern limit off southern California; north-south (N-S), extending north and south of the area; or northern (N), reaching their southern limit in this area.

For purposes of this report, only records from southern California (from Point Conception to the U.S.-Mexican border) were examined for depth and substrate. Comparable data for almost all the species examined are not available for central California or Baja California, Mexico.

RESULTS

The ranges, locations, substrates, and depths of the 29 species examined are given in Table 1. Except as indicated, the numbers given are the total numbers of stations in which the species in question occurred in each category.

Of all the species, only the spotted prawn *Pandalus platyceros* was taken at stations ranging from the shelf to bathyal areas. The other species tended to be confined to more narrow ranges of depth.

Among the 14 species found most often on the shelf, six were taken most frequently along the mainland. These six (*Cancer anthonyi, Cancer gracilis, Callianassa longimana, Pinnixa schmitti, Pinnixa occidentalis,* and *Sicyonia ingentis*) usually are found on or in soft substrates (sand, sand and mud, and mud or clay). The high number of *Pinnixa schmitti* recorded at the island stations is due to the occurrence of 116 specimens at a single station off San Miguel Island. Although *Cancer anthonyi* has been collected among rocks at King Harbor, it usually lives in protected areas along and on the inside of the breakwater, not on the exposed outer coast (Straughan 1978). It is noteworthy that the only place on the islands at which both species of *Cancer* as well as *Callianassa* spp. can be taken frequently is Santa Catalina Harbor, which has a quiet, sheltered, silty sand bottom (Straughan 1977).

Six species (*Clythrocerus planus, Crangon zacae, Erileptus spinosus, Orthopagurus minimus, Pagurus setosus,* and *Pylopagurus guatemoci*) usually were collected at island stations. These species are found on bottoms of sand and shell, pebbles, or coarse, clean sand. They were taken along the mainland in rocky areas or in places with swift currents, such as off Point Dume, off Laguna Beach, or among the red sands off Seal Beach.

Two sand shrimp (*Crangon alaskensis elongata* and *Crangon communis*), although taken most often along the islands, also occur frequently along the mainland. These widespread species do not seem to follow the same patterns of distribution as the other 12 shelf species.

Ten species were taken most often on the slopes. Of these, six were taken entirely in trawls or dredges, for which data on substrate usually could not be obtained. Five of these six (*Chorilia longipes turgida, Lopholithodes foraminatus, Munida quadrispina, Paguristes turgidus,* and *Spirontocaris sica*), although most abundant off the islands, also occur frequently along the mainland. These five have a patchy distribution, with a single trawl capturing from one to 86 individuals per tow.

Calastacus quinqueseriatus, Callianassa goniophthalma, and *Munidopsis depressa* were taken along the mainland or on the slopes of the islands facing the mainland. *Calastacus quinqueseriatus* was collected on soft substrates. *Callianassa goniophthalma* favors stagnant bottoms (D. Chivers, pers. comm.). *Parapagurus haigae* and *Argis californiensis*, however, occur most often off the islands on sand or a mixture of sand, shell, and mud.

Chorilia longipes turgida has been taken in dredges along with smooth, round boulders (Garth 1958). One small specimen collected in 1977 was clinging to a large rock. *In situ* benthic photographs, however, show this spider crab crossing a flat, sandy bottom.

Only four species were taken exclusively at stations from the basins and bathyal depths: *Lebbeus washingtonianus, Parapagurus pilosimanus benedicti, Munidopsis diomedeae,* and *Paralomis multispina*. The latter two were collected on muddy bottoms. Smears of mud on specimens of *L. washingtonianus* suggest that it, too, inhabits soft substrates (Wicksten 1978). *Parapagurus pilosimanus* in the Atlantic Ocean lives on silty clay bottoms (Menzies, George, and Rowe 1973).

TABLE 1. Distribution of species.

Species	Range	Number of stations	Number of specimens	Substrate types and number of specimens	Depth in m and number of specimens
			Mainland Shelf		
Cancer anthonyi Rathbun	N-S (Nations 1975)	M: 43 I: 5	M: 214 I: 19	Rock: 2, Gravel: 1, Sand + shell: 4, Sand: 5, Mud: 2, NR: 34	<185: 36 NR: 12
Cancer gracilis Dana	N-S (Nations 1975; AHF records)	M: 52 I: 10	M: 336 I: 36	Rock: 2, Gravel: 1, Sand + shell: 2, Sand + mud: 8, Sand: 13, Mud: 5, NR: 31	<185: 55 NR: 7
Callianassa longimana Stimpson	N-S (Schmitt 1921)	M: 17 I: 3	M: 55 I: 3	Sand: 5, Mud: 4, Clay: 5, NR: 6	<185: 18 185-923: 1 NR: 1
Pinnixa schmitti Rathbun	N-S (Schmitt 1921)	M: 29 I: 8	M: 56 I: 162	Sand + shell: 4, Sand: 12, Mud: 11, Clay: 8, NR: 2	<185: 36 185-923: 1
Pinnixa occidentalis Rathbun	N-S (Schmitt 1921)	M: 17 I: 2	M: 41 I: 2	Sand: 8, Mud: 3, Clay: 8	<185: 18 185-923: 1
Sicyonia ingentis (Burkenroad)	S (AHF records)	M: 27 I: 1 (Word and Charwat 1976)	M: 250 I: NR	NR: 27	<185: 26 185-923: 1
			Island Shelf		
Pagurus setosus (Benedict)	N (McLaughlin 1974)	M: 2 I: 41	M: 10 I: 263	Rocks: 4, Sand + shell or rocks: 24, Sand: 10, Mud: 2, NR: 3	<185: 33 185-923: 9 NR: 1
Orthopagurus minimus (Holmes)	N (McLaughlin 1974)	M: 16 I: 30	M: 172 I: 26	Sand + shell or rocks: 20, Sand: 10, Sand + mud: 1, Mud: 5, NR: 10	<185: 42 185-923: 1 NR: 3
Clythrocerus planus Rathbun	S (AHF records)	M: 3 I: 60	M: 6 I: 179	Sand + shell or rocks: 49, Sand: 13, Mud: 1	<185: 63
Erileptus spinosus Rathbun	S (Garth 1958)	M: 21 I: 122	M: 61 I: 1048	Sand + shell or rocks: 14, Sand: 6, Clay + rocks: 1, NR: 122	<185: 131 185-923: 12
Pylopagurus guatemoci Glassell	S (Walton 1954)	M: 3 I: 41	M: 5 I: 58	Sand + shell or rocks: 21, Sand: 1, Rock + mud: 2, NR: 20	<185: 35 185-923: 9
Crangon zacae (Chace)	S (Chace 1937)	M: 22 I: 72	M: 114 I: 458	Rock: 8, Sand + shell or rocks: 14, Sand: 23, Sand + mud: 8, Mud + rock or shell: 2, Mud: 15, NR: 24	<185: 57 185-923: 32 NR: 5

TABLE 1. (Cont.)

Species	Range	Number of stations	Number of specimens	Substrate types and number of specimens	Depth in m and number of specimens
			Both Shelves		
Crangon communis Rathbun	N (Schmitt 1921)	M: 14 I: 27	M: 60 I: 132	Sand + rock: 2, Sand: 4, Mud: 6, NR: 29	<185: 16 185-923: 24 NR: 1
Crangon alaskensis elongata Rathbun	N-S (Schmitt 1921)	M: 79 I: 43	M: 625 I: 529	Rock: 8, Sand + shell or rock: 12, Sand: 28, Sand + mud: 5, Mud: 4, NR: 65	<185: 94 185-923: 4 NR: 24
			Slope		
Calastacus quinqueseriatus Rathbun	N-S (Schmitt 1921)	M: 13 I: 3	M: 16 I: 4	Sand + mud: 1, Mud: 3, Clay: 5, NR: 7	<185: 2 185-923: 14
Munidopsis depressa Faxon	S (Haig 1956)	M: 10 I: 5	M: 39 I: 11	NR: 15	<185-923: 13 923-1846: 1 NR: 1
Callianassa goniophthalma Rathbun	N (Schmitt 1921)	M: 5 I: 1	M: 5 I: 1	Mud= clay: 1, NR: 5	<185: 1 185-923: 5
Parapagurus haigae De Saint Laurent	S (De Saint Laurent 1972)	M: 5 I: 36	M: 5 I: 160	Rock: 5, Sand + shell or rock: 5, Sand: 11, Mud + rock or shell: 5, Mud: 4, NR: 11	<185: 6 185-923: 35

Argis californiensis (Rathbun)	S (Wicksten 1977)	M: 3 I: 14	M: 5 I: 21	Sand + shell or rock: 3, Sand: 3, Mud + rock or shell: 1, Mud: 3, NR: 8	<185: 6 185-923: 11
Munida quadrispina Benedict	N-S (Schmitt 1921)	M: 39 I: 17	M: 81 I: 312	Sand + rock: 2, Rocks: 2, Rocks + clay: 1, Clay: 1, NR: 50	<185: 3 185-923: 51 923-1846: 2
Chorilia longipes turgida Rathbun	N (Garth 1958)	M: 26 I: 64	M: 60 I: 209	Dredged with boulders (Garth 1958)	<185: 17 185-923: 71 923-1846: 2 NR: 2
Spirontocaris sica Rathbun	N (Butler 1964)	M: 11 I: 25	M: 73 I: 150	Sand + shell: 1, NR: 35	<185: 1 185-923: 33 NR: 2
Paguristes turgidus (Stimpson)	N-S (McLaughlin 1974)	M: 8 I: 61	M: 16 I: 489	Rock: 6, Sand + shell or rock: 9, Sand: 18, Mud + shell or rock: 3, Mud: 12, NR: 21	<185: 27 185-923: 41 923-1846: 1
Lopholithodes foraminatus (Stimpson)	N (Schmitt 1921)	M: 3 I: 18	M: 4 I: 26	Rock: 1, NR: 20	<185: 7 185-923: 13 NR: 1

Table 1. (Cont.)

Species	Range	Number of stations	Number of specimens	Substrate types and number of specimens	Depth in m and number of specimens
			Basin - Bathyal		
Pandalus platyceros Brandt	N (Schmitt 1921)	M: 10 I: 33	M: 19 I: 150	Rock: 1, Mud: 1, Sand: 2, Mud + rock: 1, NR: 38	<185: 21 185-923: 12 923-1846: 3 >1846: 2 NR: 5
Lebbeus washingtonianus (Rathbun)	N (Wicksten 1978)	Total: 5	Total: 10	NR: 5	923-1846: 4 >1846: 1
Parapagurus pilosimanus benedicti De Saint Laurent	N-S (McLaughlin 1974)	Total: 6	Total: 6	NR: 6	185-923: 2 923-1846: 4
Munidopsis diomedae (Faxon)	S (Haig and Wickstein 1975)	Total: 2	Total: 10	Mud: 1, NR: 1	923-1846: 2
Paralomis multispina (Benedict)	N (Schmitt 1921)	Total: 6	Total: 6	Mud: 1, NR: 5	185-923: 1 923-1846: 5

Key to symbols: NR: not recorded. <: less than. >: greater than. M: mainland. I: island. AHF: Allan Hancock Foundation.

Of the 29 species examined, only two (*Argis californiensis* and *Crangon zacae*) seem to be confined to the Californian Province (Valentine 1966). *Munidopsis diomedeae* reaches the northern end of a range that extends as far south as Peru. *Pylopagurus guatemoci* ranges south to the Galapagos Islands. *Munidopsis depressa* and *Parapagurus pilosimanus benedicti* extend south to Central America. *Clythrocerus planus*, *Erileptus spinosus*, *Sicyonia ingentis*, *Parapagurus haigae*, and *Cancer gracilis* reach the Gulf of California and the west coast of Mexico. The remaining species range from northern Baja California or southern California to Washington, British Columbia, or Alaska.

DISCUSSION AND CONCLUSIONS

Substrate and its related parameters (organic carbon content, velocity and turbulence of bottom currents, and dissolved oxygen) influence benthic decapods of the shelf to form characteristic insular and mainland assemblages of species. The steep gradients of the bottoms off the islands, the currents around them, and the absence of major sources of silt prevent the accumulation of the soft substrates favored by digging species more common to the mainland. In Santa Catalina Harbor, where protected sand is present, mainland species can occur.

Insular species occur along the mainland only in isolated areas of suitable substrates. Input of large masses of particulate material, whether from large sewage outfalls or dredge tailings, easily could bury suitable habitats for the insular species. Early records have not been analyzed yet to find out if recent human activities, such as the installation of the large sewage outfalls off Los Angeles County, have destroyed some of these patches of coarse sediments. It seems likely, however, that such changes could alter the assemblages of decapods in such areas from insular to mainland types.

More specimens inhabiting the slopes and basins were taken off the islands than along the mainland. This seeming abundance near the islands may be due to the ease of sampling. Because of the sharp drop-offs along the shores of the islands, deep water is available for study closer to shore than it is along the mainland.

On the whole, species of the slopes, basins, and bathyal areas seem to be adapted to soft sediments, which are prevalent in this range of depths (Shepard 1963). I have found that *Chorilia longipes turgida* may stay near isolated outcrops of rock or move from one rocky area to another, as does the shallow subtidal decorator crab *Loxorhynchus crispatus*.

Lopholithodes foraminatus may follow a temperature gradient in its distribution. McCauley (1972) found the crab at 42 to 200 m off Oregon, while Pereyra and Alton (1972) stated that it was most common off Oregon in the outer sublittoral zone, at 50 to 100 fathoms (92 to 185 m). At 14 of the 21 stations where the crab was taken in southern California, it occurred at 190 m or deeper. However, it does range into water as shallow as about 20 m off the Palos Verdes peninsula (L. Ogilvy, pers. comm.).

Unequal distribution of food may cause the patchy distribution of decapods of the slope. Four or more *Chorilia longipes turgida* and *Lopholithodes foraminatus* were taken at a time in baited traps by the R. V. *N. B. Scofield* in 1969 and by the M. V. *Lady Anne* in 1977. *Paralomis multispina* also has been collected in traps (Allan Hancock Foundation unpubl. records).

Of the decapods of the slopes and deeper areas, only *Calastacus quinqueseriatus* and *Callianassa goniophthalma* belong to groups that dig permanent burrows. The other species, taken in baited traps, trawls, and dredges, or photographed *in situ*, seem to be climbers, walkers, shallow diggers, and short-distance swimmers. None are known to be commensals, as are *Pinnixa* spp. Perhaps lack of sufficient concentrations of food in the sediments, or the consistency of the sediments, causes the decapods to be adapted to foraging across wide areas of bottom.

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