

Natural History and Occurrence of Opisthobranch Gastropods from the Open Coast of San Mateo County, California

BY

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(1 Map)

INTRODUCTION

TO DATE, annotated checklists for the opisthobranchs of three Californian counties have been published (SPHON & LANCE, 1968; ROLLER & LONG, 1969; and GOSLINER & WILLIAMS, 1970). Helpful as these are, we departed from their style to give a more comprehensive survey of the opisthobranchs known to occur in San Mateo County, California.

During the five-year period 1966 to 1970, we made 32 intertidal collection and study trips to six localities along the open coast of San Mateo County (see Map):

24 June 1966 - Pescadero Beach, G/W²
 20 July 1966 - Frenchman's Reef, G/W
 2 August 1966 - Moss Beach, G/W
 9 August 1967 - Moss Beach, Wh
 23 August 1967 - Moss Beach, Wh
 4 September 1967 - Moss Beach, Wh
 16 December 1967 - Moss Beach, Wh
 27, 28, 29, 30 December 1967 - Moss Beach, Wh
 18 May 1968 - Moss Beach, G/W
 8, 23 August 1968 - Moss Beach, Wh
 16, 18, 19 December 1968 - Moss Beach, Wh
 17 January 1969 - Pescadero Beach, B
 1 February 1969 - Moss Beach, B
 8, 19 April 1969 - Moss Beach, B

3 May 1969 - Pescadero Beach, B
 30 June 1969 - Pillar Point, Wh
 8, 20 December 1969 - Moss Beach, B
 3 January 1970 - Año Nuevo Point, B
 6 January 1970 - Pebble Beach, B
 19 February 1970 - Moss Beach, B
 25 April 1970 - Moss Beach, B
 26 April 1970 - Pebble Beach, B
 4 July 1970 - Moss Beach, G/W
 18 July 1970 - Moss Beach B/G/W

The first half of this paper includes our collecting data and life history information. The species are arranged alphabetically. An asterisk (*) in front of the species name indicates a new record for the county; a plus sign (+) indicates that other authors have reported the species from San Mateo County, but that we did not obtain it during our study.

The second half presents an analysis of the statistics we gathered regarding the relative and absolute frequency of the species. The conclusions presented should be considered as open-ended, *i. e.*, a preliminary survey based on collecting records from 9 months of the year. We hope that this will encourage further research in this style by our associates in opisthobranch studies.

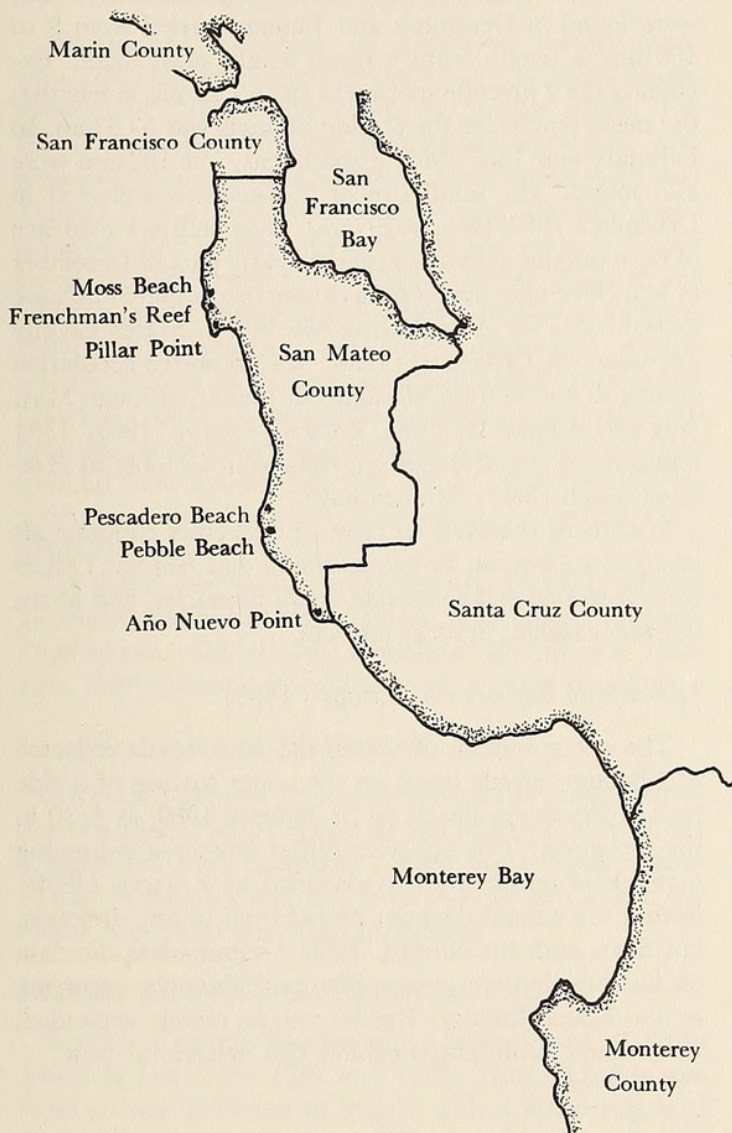
NATURAL HISTORY

**Acanthodoris hudsoni* MacFarland, 1905

On 4 July 1970, we obtained 2 *Acanthodoris hudsoni* in the low tide zone at Moss Beach. One animal was crawling over the alga *Egregia*, while the second was inside a burrowing-clam hole in the shale rocks.

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² The initials indicate which authors gathered the information on that date: G/W - Gosliner and Williams; Wh - Wharton; B - Bertsch



Map of San Mateo County and adjacent areas, California

Acanthodoris lutea MacFarland, 1925

The original description of *Acanthodoris lutea* was based on one specimen from Cayucos, San Luis Obispo County, California (collected 9 February 1921), and one specimen from the tide pools of Colorado Reef, off Moss Beach, collected by MacFarland on 26 July 1922 (MACFARLAND, 1925: 60 - 65). The Cayucos individual was 22.5 mm long, and the Moss Beach specimen measured 17.5 mm in length. MACFARLAND (1966: 120 - 121) repeats his original descriptive material with no mention of any further animals having been found, but he adds that its habitat is in rocky tide pools at extreme low tide. LANCE (1961: 67) states that *A. lutea* is seasonally abun-

dant at Moss Beach. Farther south, at Santa Monica Bay (Los Angeles County), it is abundant during the fall and winter, but rare during spring and summer (TURNER, EBERT & GIVEN, 1969: 132).

Based on the 40 specimens of *Acanthodoris lutea* that we found at Moss Beach, this is the commonest *Acanthodoris* in the county. The 14 *A. lutea* collected in August 1968 varied in length from 10 mm to 25 mm, with a mean of 18.3 mm. The length of 21 animals in December 1968 varied from 17 mm to 34 mm, with a mean of 23.4 mm. The December mean is 27% greater than the August mean. The total mean length for both months was 21.4 millimeters.

Nearly half of the specimens were found crawling on bare rock surfaces; 6 were crawling on the alga *Iridaea*, and 3 were on crustose coralline algae. Individual specimens were found on *Odonthalia*, *Prionitis*, *Hymenena*, *Phyllospadix*, *Botryoglossum*, and *Egregia*.

These animals reproduce at least during December in San Mateo County, although the measurement data given above for August and December would seem to indicate reproductive behavior also during the summer. On 9 December 1968 2 pairs (measuring 22-20 mm and 28-27 mm) were observed on rocks copulating.

Acanthodoris nanaimoensis O'Donoghue, 1921

STEINBERG (1963: 64) and ROLLER (1970: 371) synonymized *Acanthodoris columbina* MacFarland, 1926, with the earlier *A. nanaimoensis*. When Steinberg proposed the synonymy of these species, she mentioned collecting *A. nanaimoensis* from Moss Beach, but gave no additional data. MACFARLAND (1926: 94 - 100) named *A. columbina* based on 6 specimens collected from the rocky tide pools of Moss Beach on 26 July 1922. He added no additional information regarding the habitat of this species in his Pacific Coast monograph (1966: 121 - 123).

We obtained only 4 specimens of *Acanthodoris nanaimoensis*, all from the Moss Beach region. One was on *Egregia*, and 2 were under rocks.

Recent papers by ROLLER & LONG (1969: 425) and LEE & BROPHY (1969: 220) have extended the range of *Acanthodoris nanaimoensis* to San Luis Obispo and Santa Barbara Counties, but it is still rare throughout the southern part of its distribution.

**Acanthodoris rhodoceras* Cockerell & Eliot, 1905

The sporadic occurrence of *Acanthodoris rhodoceras* yielded 7 specimens from Moss Beach and Pillar Point. The lengths of the living animals were 15, 16, 17, and 27 mm. We found no published data on *A. rhodoceras*

from San Mateo County, but our measurements are larger than for material reported from San Diego (10 mm, MACFARLAND, 1925: 55 - 60); Point Loma (4, 7, and 13 mm, MARCUS, 1961: 26 - 27), San Pedro (12 mm, COCKERELL & ELIOT, 1905: 38 - 39), and Dillon Beach (15 mm, MARCUS, 1961: 26 - 27). MACGINITIE & MACGINITIE (1949: 363) gave no collecting data for their photograph of a 14 mm *A. rhodoceras*.

Specimens occurred on *Iridaea*, *Egria*, and an erect coralline alga.

Aegires albopunctatus MacFarland, 1905

LANCE (1966: 75) reported that *Aegires albopunctatus* is one of the most abundant species during the summer months at Moss Beach.

We found this negatively phototactic polycerid on the algae *Phyllospadix*, *Botryoglossum*, *Egria*, and *Iridaea*.

**Aeolidia papillosa* (Linnaeus, 1761)

A cosmopolitan nudibranch, *Aeolidia papillosa* occurred twice at Moss Beach high in the upper tide zone. The animals were 11 and 40 mm in length.

Aeolidia papillosa preys on sea anemones; data from worldwide localities have been given by THOMPSON (1964: 297), MACFARLAND (1966: 373), ROBSON (1966: 344 - 356), ROSS (1967: 313), ROSIN (1969: 74), and BARRETT (1969: 68 - 69). Both our specimens were found preying on the sea anemone *Epiactis prolifera* Verrill, 1869, a new feeding record for *A. papillosa*. When the larger specimen was kept in a small aquarium for 3 days along with an *E. prolifera* attached to a rock, the nudibranch ate the entire sea anemone. The total consumption of a sea anemone by our specimen differs from THOMPSON's (1964: 279) description of considerable wastage accompanying the feeding of *A. papillosa* because of the unnatural laboratory condition in which our animal was placed.

+*Ancula pacifica* MacFarland, 1905

SPHON & LANCE (1968: 82) and ROLLER & LONG (1969: 425) listed Moss Beach as the northern limit of *Ancula pacifica*. Although its range has been extended to Duxbury Reef in Marin County (GOSLINER & WILLIAMS, 1970: 176), and BEHRENS (1971: 297 - 298) considers it relatively common in San Francisco Bay during the early summer months, we did not collect any specimens of this goniodorid in San Mateo County.

**Anisodoris nobilis* (MacFarland, 1905)

Thirty-two specimens of *Anisodoris nobilis* were found at Moss Beach, Frenchman's Reef, Pebble Beach, and

Pillar Point. The specimens of this large discodorid that were found in December and January varied from 9 to 100 mm in length, with a mean length of 48.8 mm. Excluding the 2 juvenile specimens (9 and 19 mm in length), the mean length for the 8 adult animals was 57.5 mm. In February and June 1969, 2 specimens over 100 mm were also found. The small size of 2 specimens collected in December 1967 (9 and 19 mm) gives indirect evidence of reproductive activity during the early part of December or late November. Exact data cannot be computed because growth rates for *Anisodoris nobilis* in San Mateo County are unknown. COSTELLO (1938: 324) reported copulation among *A. nobilis* from Monterey in January through May, July and August; TURNER, EBERT & GIVEN (1969: 133) found the orange-colored egg ribbons in October at Hermosa Beach (Santa Monica Bay).

Specimens occurred on crustose and erect coralline algae, *Botryoglossum*, *Prionitis*, *Ptilota* and *Iridaea*. Others were found on yellow sponge, small barnacles, and above the water surface in rocky crevices.

**Antiopella barbarensis* (Cooper, 1863)

The one specimen of *Antiopella barbarensis* collected was floating upside down on the water surface of a tide pool at Pescadero Beach on 17 January 1969, at 4:30 in the afternoon. This behavior differs from the swimming methods of opisthobranchs classified by FARMER (1970) in that the animal does not propel itself in any direction, but floats with the current. Table 1 summarizes the data on floating that we possess for opisthobranchs occurring in San Mateo County. This list can be readily expanded, since many nudibranchs exhibit this behavioral trait.

Table 1

Floating behavior exhibited by opisthobranch species from San Mateo County

Species	Floating	
	in the field	in lab. aquaria
<i>Antiopella barbarensis</i>	×	
<i>Cadlina luteomarginata</i>		×
<i>Coryphella trilineata</i>	×	×
<i>Dendronotus albus</i>		×
<i>Dendronotus frondosus</i>	×	
<i>Dialula sandiegensis</i>		×
<i>Dirona picta</i>	×	×
<i>Doriopsilla albopunctata</i>	×	×
<i>Hopkinsia rosacea</i>	×	×
<i>Pleurobranchus strongi</i>		×
<i>Rostanga pulchra</i>		×
<i>Trinchesia lagunae</i>	×	×
<i>Triopha maculata</i>	×	×

**Archidoris montereyensis* (Cooper, 1862)

Twenty-four specimens of *Archidoris montereyensis* were collected year-round in the county at Moss Beach, Frenchman's Reef, Pillar Point, and Pebble Beach. The length of 16 animals varied from 11 mm to 62 mm, with a mean length of 35.5 mm. Eleven adult specimens (over 25 mm) had a mean length of 44 mm. Juvenile specimens occurred in August, December, and January. Copulation probably occurred at least a month prior to the finding of these immature specimens (McGOWAN & PRATT, 1954: 274). COSTELLO (1938: 324) reported *A. montereyensis* mating in January to April and in July, while MARCUS (1961: 17) states that spawning occurs in Monterey Bay from November to April. Combining the data from all these sources indicates that *A. montereyensis* reproduces during the entire year along the central California coast.

We found *Archidoris montereyensis* crawling among *Tubularia*, and on the algae *Iridaea*, *Hymenena*, *Smithora*, *Phyllospadix*, *Odonthalia*, *Gigartina canaliculata*, *Prionitis*, *Botryoglossum*, *Corallina*, and crustose coralline.

**Archidoris odhneri* (MacFarland, 1966)

Archidoris odhneri (transferred from the genus *Austro-doris* by BURN, 1968) is rare in San Mateo County. Only 3 specimens were collected, 2 from Moss Beach (about 95 mm in length) and one from Año Nuevo Point. We found *A. odhneri* crawling on *Iridaea*.

**Cadlina flavomaculata* MacFarland, 1905

Sixteen *Cadlina flavomaculata* were found at Moss Beach in December 1967 and 1968. They varied in size from 10 mm to 24 mm in length, with a mean length of 15.5 mm.

The animals were crawling on bare rock, bryozoan, a small gastropod, and on the algae *Botryoglossum*, *Hymenena*, *Iridaea*, *Ptilota*, and erect coralline.

Cadlina luteomarginata MacFarland, 1966

BERTSCH (1969: 231) reported *Cadlina luteomarginata* from San Mateo County, without giving any habitat information.

Moss Beach, Frenchman's Reef, and Pebble Beach yielded 26 specimens of *Cadlina luteomarginata*, ranging in length from 14 mm to 50 mm (mean: 27.5 mm). The animals occurred on the bottom of bare rocky tide pools, and crawling over *Aglaophenia*, colonial ascidians, and various algae: crustose and erect coralline, *Iridaea*, *Phyllospadix*, *Botryoglossum*, *Odonthalia*, and *Gigartina canaliculata*. Gosliner and Williams found sponge spicules and undigested choanocytes in the digestive tract of *C. luteomarginata* collected in Marin County.

Mating was observed between a 20 mm and a 25 mm long *Cadlina luteomarginata* at Moss Beach on 28 August 1968. The animals were on the bare rock. COSTELLO (1938: 326) observed their egg ribbons in Monterey during the winter months (December to March). In the Vancouver Island region O'DONOGHUE & O'DONOGHUE (1922: 138) found the nidosomes of this species during April, May, and June.

Cadlina modesta MacFarland, 1966

Cadlina modesta has been recorded from Moss Beach (BERTSCH, 1969: 231 - 232) in association with the algae *Gastroclonium coulteri* and *Corallina*. Since then, we have found 16 specimens of *C. modesta* from Moss Beach, Pillar Point, and Pebble Beach. These animals were crawling over *Codium*, *Egregia*, and *Iridaea*.

**Coryphella trilineata* O'Donoghue, 1921

Seven specimens of *Coryphella trilineata* occurred at Moss Beach and Pillar Point during the late spring and early summer months. They were on a bare rock surface, on encrusting bryozoan underneath a rock, and on *Iridaea* and *Phyllospadix*. MACFARLAND (1966: 321) reported *Coryphella fisheri* (synonymized with *C. trilineata* by ROLLER, 1970: 372) from Monterey Bay on the hydroid colonies on the algae *Gigartina canaliculata* and on the fronds of *Macrocystis*.

+*Dendronotus albus* MacFarland, 1966

Based on the collecting data of James Lance, ROBILLIARD (1970: 469) reports *Dendronotus albus* from the low intertidal of Moss Beach on 13 June 1964. We did not collect any specimens of this species.

**Dendronotus frondosus* (Ascanius, 1774)

We found 2 specimens of *Dendronotus frondosus* (25 mm and 35 mm long) at Frenchman's Reef, sheltered in rocky crevices. *Dendronotus frondosus* is known to feed on hydroids, with which they are usually associated (TURNER, EBERT & GIVEN, 1969: 135).

**Diaphana californica* Dall, 1919

One specimen of the cephalaspidean *Diaphana californica* was obtained at Moss Beach. It was crawling on *Iridaea*.

Diaulula sandiegensis (Cooper, 1862)

Diaulula sandiegensis occurred quite commonly at Moss Beach, where it has been previously reported (BERTSCH,

1969: 231). The species was also found at Pillar Point and Pebble Beach. We saw 54 specimens during our collecting trips to the intertidal regions of San Mateo County. Twenty-seven animals were measured, varying in total length from 14 mm to 40 mm, with a mean length of 26 mm. Only 4 animals were under 20 mm in length.

This species was found from the upper reaches of the mid-tide zone to the extreme lowest tide zone. One specimen was found in a low-tide rock crevice (3 feet deep by 6 inches wide) that also contained the orange solitary coral *Balanophyllia elegans* Verrill, 1864, and the nudibranch *Tritonia festiva* (Stearns, 1873). Another was crawling over coralline algae in the tide pool habitat of the sea urchin *Strongylocentrotus purpuratus* (Stimpson, 1857). We have found *Diaulula sandiegensis* crawling on bare rock, red sponge, colonial ascidians, a crustose red alga, crustose and erect coralline algae, and on *Iridaea*, *Egria*, *Gelidium*, *Prionites*, *Botryoglossum*, *Microcladia*, *Rhodymenia*, and *Hymenena*.

In aquaria, *Diaulula sandiegensis* frequently floated upside down on the water surface.

**Dirona picta* Cockerell & Eliot, 1905

Two specimens of *Dirona picta* were found at Frenchman's Reef. There are no other data for *D. picta* in San Mateo County, although MACFARLAND (1912: 518) reports its abundance in nearby Monterey Bay during the summer months and GOSLINER & WILLIAMS (1970: 178) consider it common in Marin County.

The stomach contents of one specimen consisted of the avicularia of a *Bugula*-type bryozoan.

**Discodoris heathi* MacFarland, 1905

Nine specimens of *Discodoris heathi* were obtained from Moss Beach and Frenchman's Reef throughout the year. We have little ecological data on this species. One animal was crawling on *Iridaea*, and another on *Botryoglossum*.

**Doriopsilla albopunctata* (Cooper, 1863)

Ten specimens of *Doriopsilla albopunctata* were found at Moss Beach, Frenchman's Reef, and Pebble Beach. Several were on *Iridaea*, and others were crawling over bare rock.

+*Doto kya* MARCUS, 1961

ROLLER & LONG (1969: 427) listed the range of *Doto kya* as Moss Beach to Shell Beach. Although its range has recently been extended north to Marin County (GOSLINER

& WILLIAMS (1970: 178)), we found no representative of this species in San Mateo County.

**Doto wara* Marcus, 1961

During June 1969 and July 1970, a total of 4 specimens of *Doto wara* was found at Moss Beach and Pillar Point. Two of the animals were on *Aglaophenia*.

+*Elysia hedgpethi* Marcus, 1961

MACFARLAND (1966: 53) reports finding 2 specimens of *Elysia bedeckta* MacFarland, 1966 (synonymized with *E. hedgpethi*; see ROLLER, 1970: 371, and SPHON & LANCE, 1968: 79) on *Ulva* at Moss Beach in June 1921 and 1922. We did not obtain this species during our collecting in San Mateo County.

**Eubbranchus rustyus* (Marcus, 1961)

Synonyms: *Eubbranchus occidentalis* MacFarland, 1966 (see ROLLER, 1970: 372); *Capellinia rustya* Marcus, 1961 (see EDMUNDS & KRESS, 1969: 905-907).

We obtained 2 specimens of *Eubbranchus rustyus* from Moss Beach. They were crawling on *Egria* and *Iridaea*. This species has been found in Monterey Bay on *Obelia* (MARCUS, 1961: 49) and on colonies of *Hydractinia* that are attached to holdfasts of *Cystoseira osmundacea* (MACFARLAND, 1966: 325).

Hermisenda crassicornis (Eschscholtz, 1831)

MACFARLAND (1966: 363) has collected *Hermisenda crassicornis* at Moss Beach. We found 9 specimens at Moss Beach, Pillar Point, and Pescadero Beach, varying in length from 8 mm to 17 mm. One was quite high in the intertidal zone, in a sandy region covered with *Zostera*. Other *H. crassicornis* were on bare rock, *Aglaophenia*, crustose coralline, *Iridaea* and *Egria*.

Hermisenda crassicornis is quite active in confinement and a voracious predator on members of its own species and other opisthobranchs (MACFARLAND, 1966: 363), and on hydroids (TURNER, EBERT & GIVEN, 1969: 136). Its carnivorous behavior includes shelled mollusks as well. One specimen from Santa Barbara that Bertsch kept in a 90-gallon capacity tank devoured the prosobranch gastropod *Acmaea insessa* (Hinds, 1842) and the bivalve *Tivela stultorum* (Mawe, 1823). *Acmaea insessa* had died while attached to the glass wall of the aquarium. *Hermisenda* wrapped its foot around the perimeter of the shell, reached underneath to the flesh of the limpet, and plucked off pieces of the meat. The nudibranch and

the dead *Acmaea* slid to the bottom of the aquarium. *Hermisenda* curled up inside the shell, resting on the gravel, and finished eating the entire fleshy part of the limpet. The scavenging habits of *H. crassicornis* were again shown when it ate parts of a dead Pismo clam (*Tivela stultorum*). In similar laboratory conditions, a *H. crassicornis* that Gosliner and Williams collected from Marin County ate part of the foot of a dead *Lamellaria*.

**Hopkinsia rosacea* MacFarland, 1905

Hopkinsia rosacea occurred at Moss Beach and Pescadero Beach. The 7 specimens collected had extremes in length from 13 mm to 25 mm, with a mean of 20 mm. One was in the high intertidal zone, attached to an overhanging rock above the water surface; others were under the water on *Corallina*, *Gastroclonium*, and the bare rock.

**Laila cockerelli* MacFarland, 1905

We found 13 specimens of *Laila cockerelli* at Moss Beach, Pillar Point, and Pescadero Beach. The largest was 24 mm long, the smallest, 10 mm.

Laila cockerelli was found on bare rock, *Membranipora*, and *Botryoglossum*. Nine of the animals were collected from *Iridaea*.

**Onchidoris hystricina* (Bergh, 1878)

Only 2 specimens of *Onchidoris hystricina* were found, both at Moss Beach. One was crawling among *Phyllospadix*, and the other was on *Iridaea*.

**Pleurobranchus californicus denticulatus* MacFarland, 1966

One 42 mm long specimen of *Pleurobranchus californicus denticulatus* was found at Pebble Beach. Because of its rarity in San Mateo County, we have insufficient material to propose a solution to the taxonomic problems of this species, other than stating that we agree with ROLLER (1970: 372-373) that *P. californicus denticulatus* should be given specific status.

**Pleurobranchus strongi* MacFarland, 1966

This species was also rare; we found 2 specimens, a 24 mm individual at Pebble Beach, and a 20 mm animal at Moss Beach. The former was underneath a large rock in the mid-tide zone; the latter was crawling over the algae *Phyllospadix* and *Iridaea*. The animal from Pebble Beach was kept alive in an aquarium, where it exhibited the floating behavior.

As with the preceding species, the taxonomic status of *Pleurobranchus strongi* is unsatisfactory at present.

**Precuthona divae* Marcus, 1961

One specimen of *Precuthona divae* (synonym: *Cuthona rosea* MacFarland, 1966; see SPHON & LANCE, 1968: 80, and ROLLER, 1970: 372) was found crawling on *Iridaea* at Moss Beach in July 1970. In the Monterey Bay region the species has been reported as very common during the summer months on the pink hydroid *Hydractinia*. The type locality of *P. divae* is north of San Mateo County, at Dillon Beach, Marin County. GOSLINER & WILLIAMS (1970: 179) state that it occurs frequently in Marin County. We were not able to determine the cause of its extreme rarity in San Mateo County, midway between the localities from which MacFarland and Marcus obtained their material.

**Rostanga pulchra* MacFarland, 1905

Although previously unreported from San Mateo County, *Rostanga pulchra* occurred commonly throughout the year at 5 of our collecting stations: Moss Beach, Frenchman's Reef, Pillar Point, Pescadero Beach, and Pebble Beach. It would probably be found at Año Nuevo Beach if more extensive collecting had been done there. The year-round occurrence of *R. pulchra* concurs with the observations of RICKETTS & CALVIN (1968: 53), although HURST (1967: 260-261) pointed out that it seems to occur seasonally during the summer months in the northern extreme of its range at Friday Harbor.

We collected 43 specimens of *Rostanga pulchra*, varying in length from 3 mm to 16 mm, with a mean length of 7.7 mm. Over 75% of the animals were smaller than 10 mm in total length. This is slightly smaller than the average size of 8-12 mm given by MACFARLAND (1966: 168).

The food preferences of *Rostanga pulchra* for the sponges *Plocamia lithophoenia* de Laubenfels, *P. karykinos* de Laubenfels, *Acarnus erithacus* de Laubenfels, and *Ophlitaspongia pennata* Labbe has been well documented (COOK, 1962: 194-196; MACFARLAND, 1966: 168). Most authors state that *R. pulchra* is commonly found on red sponge (*e. g.*, MACFARLAND, 1906: 121), but in our collecting experience in San Mateo County, we found only 2 specimens of this dorid (3 mm and 5 mm; both at Moss Beach) on red sponge. The substrate it was found on varied from bare rock, an empty muricid shell, and colonial ascidians, to the algae *Zostera*, *Botryoglossum farlowianum*, crustose and erect coralline, *Phyllospadix*, *Iridaea*, *Hymenena*, and *Egregia*. Perhaps more than

anything else, the wide range of substrates emphasizes the unpredictable occurrence of nudibranchs. Although preferred habitats may exist, the collector should not limit himself to these, but must be prepared to find particular species in contact with previously unassociated habitats. There is a dearth of information on nudibranch grazing patterns and techniques. Consequently, not enough is known about the behavior of nudibranchs to state definitely that when they are found on a non-food substrate they are in transit to edible material.

**Trinchesia abronia* (MacFarland, 1966)

Two specimens of *Trinchesia abronia* were obtained at Moss Beach in July 1970. One was on bare rock, the other was crawling on *Iridaea*. In San Luis Obispo County, LONG (1969: 281) has found *T. abronia* crawling over the alga *Desmarestia herbacea*.

**Trinchesia albocrusta* (MacFarland, 1966)

Three specimens of *Trinchesia albocrusta* were found at Moss Beach on *Egregia* and *Iridaea*.

**Trinchesia lagunae* (O'Donoghue, 1926)

The 4 specimens of *Trinchesia lagunae* (originally *Herveya lagunae*, O'DONOGHUE, 1926: 231 - 232; see ROLLER, 1969: 421, for synonymy) were collected during July and August at Moss Beach and Frenchman's Reef. One was found floating upside down on the water surface of a tide pool. Two others were on *Iridaea*.

**Triopha* sp.

The genus *Triopha* is still in need of systematic revision despite the lapse of 10 years since STEINBERG (1961: 60 to 61) and MARCUS (1961: 22 - 24) questioned the status of the 9 described (and ill-described) species of *Triopha* occurring on the American Pacific coast. *Triopha* sp. was used by SPHON & LANCE (1968: 81) and ROLLER & LONG (1969: 428) to designate a small, orange triophid of unknown taxonomic status. We obtained 12 specimens of this form, all from Moss Beach. Seven individuals that we measured varied in length from 6 mm to 14 mm, with a mean of 9.9 mm. One animal was crawling over *Iridaea*.

**Triopha carpenteri* (Stearns, 1873)

A total of 68 *Triopha carpenteri* was obtained at Moss Beach, Frenchman's Reef, Pillar Point, and Pescadero Beach. The species was most common during the summer months of June and July, when 81% of our specimens (55 animals) were collected. *Triopha carpenteri* occurred on bare rock, on the bryozoan *Membranipora*, and on the

algae *Corallina*, *Phyllospadix*, *Microcladia*, *Prionitis*, *Hymenena*, and *Botryoglossum*.

The animal also occurs with irregular seasonality in Santa Monica Bay (TURNER, EBERT & GIVEN, 1969: 138).

**Triopha maculata* MacFarland, 1905

We found 12 specimens of *Triopha maculata* at Moss Beach, Pillar Point, and Frenchman's Reef. A few were on *Iridaea*; one was inside an empty burrowing-clam hole that had been dug in shale. Greyish colonial tunicates were in this burrow, and *T. maculata* was in direct contact with them. This specimen, measuring 13 mm in length, appeared to be feeding on the tunicates.

+ *Tritonia exsulans* Bergh, 1894

We did not obtain any *Tritonia exsulans* from San Mateo County. BERGH (1894: 150 - 152) reported dredging *T. exsulans* from 43 fathoms off Año Nuevo Point. O'DONOGHUE (1926: 204), SMITH & GORDON (1948: 180), and MACFARLAND (1966: 230) repeat Bergh's collecting data.

Tritonia festiva (Stearns, 1873)

STEINBERG (1961: 62) and BERTSCH (1969: 231) have reported collecting *Tritonia festiva* from Moss Beach. BABA (1968: 258 - 259; and 1969: 132) recently extended its range to Japan, but he did not furnish any ecological data.

We found 16 specimens of *Tritonia festiva* at Moss Beach and Pebble Beach. One was in a rock crevice with orange solitary coral and *Diaulula sandiegensis*; others were attached to the side of rocks, above the water surface, or crawling over crustose and erect coralline, *Microcladia*, and *Iridaea*.

SPECIES DIVERSITY

A characteristic feature of biological communities is that they contain comparatively few species that are common, and a comparatively large number of species that are rare at any given locus in time and space (ODUM, 1963: 28). Previous checklists of nudibranchs and their allies from the California coast (*e. g.*, the most recent, GOSLINER & WILLIAMS, 1970) have not quantitatively compared species frequencies, but have used general terms, such as "common" or "rare" to indicate varying occurrences of individual species. To more adequately present a picture of the opisthobranch species structure in San Mateo County, we tabulated precise frequency differentials between the species we collected.

Table 2

Occurrence of the opisthobranch species on various substrates

	<i>Acanthodoris hudsoni</i>	<i>Acanthodoris lutea</i>	<i>Acanthodoris nanaimoensis</i>	<i>Acanthodoris rhodoceras</i>	<i>Aegires albopunctatus</i>	<i>Aeolidia papillosa</i>	<i>Anisodoris nobilis</i>	<i>Antipella barbarensis</i>	<i>Archidoris montereyensis</i>	<i>Archidoris odhneri</i>	<i>Cadlina flavomaculata</i>	<i>Cadlina luteomarginata</i>	<i>Cadlina modesta</i>	<i>Coryphella trilineata</i>	<i>Dendronotus frondosus</i>	<i>Diaphana californica</i>	<i>Diaulula sandiegensis</i>	<i>Dirona picta</i>	<i>Discodoris heathi</i>	<i>Doriopsilla albopunctata</i>	<i>Doto wara</i>	<i>Eubranchius rusticus</i>	<i>Hermisenda crassicornis</i>	<i>Hopkinsia rosacea</i>	<i>Laila cockerelli</i>	<i>Onchidoris hystricina</i>	<i>Pleurobr. calif. dent.</i>	<i>Pleurobranchius strongi</i>	<i>Preculhona divae</i>	<i>Rostanga pulchra</i>	<i>Trinchesia abronia</i>	<i>Trinchesia albocrusta</i>	<i>Trinchesia lagunae</i>	<i>Triopha sp.</i>	<i>Triopha carpenteri</i>	<i>Triopha maculata</i>	<i>Tritonia festiva</i>	
On water surface																																						
Bare rock		•									•	•								•			•	•	•					•	•				•		•	
Under rocks, in rocky crevices			•												•									•				•									•	
Burrowing clam hole	•																																			•		
Red sponge																•													•									
<i>Epiactis prolifera</i>					•																																	
<i>Aglaophenia</i>											•									•		•																
<i>Tubularia</i>									•																													
Bryozoan										•					•										•									•				
Colonial tunicates											•																		•							•		
ALGAE:																																						
<i>Botryoglossum</i>		•			•		•				•	•												•						•					•			
<i>Codium</i>													•																									
<i>Corallina</i>										•														•										•				
Crustose coralline		•																																				
Erect coralline					•						•	•																		•							•	
<i>Egria</i>	•	•	•	•	•																	•																
<i>Gastroclonium</i>																																						
<i>Gelidium</i>																																						
<i>Gigartina</i>									•			•																										
<i>Hymenena</i>	•								•		•																			•								
<i>Iridaea</i>	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
<i>Microcladia</i>																																						
<i>Odontohalia</i>	•								•			•																										
<i>Phyllospadix</i>	•				•				•			•																										
<i>Prionitis</i>	•								•			•																										
<i>Ptilota</i>									•																													
<i>Rhodomenia</i>																																						
<i>Smithora</i>									•																													
<i>Zostera</i>																																						

Tables 3 and 4 present the total number of specimens obtained during each month we collected. Table 5 is the cumulative number of specimens caught per month. Monthly frequency varies greatly, both because of the natural history patterns of the animals and because of the different amounts of collecting in each month and particular idiosyncrasies of the 4 collectors. To reduce the second factor to a minimum, we compared the annual and total percentages of all captures represented by each species (Table 6).

Seasonality can be attributed definitely only to a few species for which we have sufficient data (arbitrarily designated as over 20 total specimens collected of a species). *Acanthodoris lutea*, *Aegires albopunctatus*, and *Triopha carpeni* have a high number of total specimens collected, but actually occurred rarely. The total number represents large numbers of the animals that we found in one month (respectively: December 1968; July 1970; and June 1969 and July 1966). Accordingly, despite the great amount of total specimens, it would be erroneous

Table 3

Number of specimens caught each month, 1966 - 1968

	1966						1967		1968		
	Jan	Feb	Apr	May	June	Dec	Jan	Feb	Apr	July	
<i>Acanthodoris lutea</i>									12	21	
<i>Acanthodoris nanaimoensis</i>			1								
<i>Acanthodoris rhodoceras</i>									4		
<i>Aegires albopunctatus</i>			5						1	1	
<i>Aeolidia papillosa</i>									1		
<i>Anisodoris nobilis</i>			12				2		6		
<i>Archidoris montereyensis</i>			3				2		5	8	
<i>Archidoris odhneri</i>				2							
<i>Cadlina flavomaculata</i>							1		15		
<i>Cadlina luteomarginata</i>			1				6		9	7	
<i>Coryphella trilineata</i>								1			
<i>Dendronotus frondosus</i>			2								
<i>Diaulula sandiegensis</i>					1		5		3	13	
<i>Dirona picta</i>			2								
<i>Discodoris heathi</i>			3	1						1	
<i>Doriopsilla albopunctata</i>			4				1				
<i>Hermisenda crassicornis</i>						1	2		1		
<i>Hopkinsia rosacea</i>		2			2		1		1		
<i>Laila cockerelli</i>		1							2	4	
<i>Onchidoris hystericina</i>									1		
<i>Pleurobranchus strongi</i>				1							
<i>Rostanga pulchra</i>					2	1	13	1	2	5	
<i>Trinchesia lagunae</i>			1						1		
<i>Triopha carpenteri</i>		3	25				1		7	4	
<i>Triopha maculata</i>			5								
<i>Tritonia festiva</i>				1					2	1	

to consider these species as "common" in San Mateo County, since they were found irregularly. These 3 species exhibited a non-yearly seasonality.

In contrast, *Anisodoris nobilis* occurred with regular frequency, although in lesser total numbers. It was more common in the summer months (21 specimens, of 32 total, were found in June and July).

By far the commonest species were *Diaulula sandiegensis* and *Rostanga pulchra*. On any one collecting trip, we would feel most assured of obtaining these 2 species. Our data show that both species were most common during the winter months (December to February), when over 50% of the specimens were collected.

When all specimens are totalled for each month (Table 5), the greatest amounts were collected in July and December (34.7% and 30.6% of the total specimens). However, if 3 summer months and 3 winter months are considered as one time period each, the opisthobranchs were

Table 4

Number of specimens caught each month, 1969 - 1970

	1969					1970				
	June	July	Aug	Aug	Sep	Dec	May	Aug	Dec	
<i>Acanthodoris hudsoni</i>										2
<i>Acanthodoris lutea</i>	1				1					3
<i>Acanthodoris nanaimoensis</i>										3
<i>Acanthodoris rhodoceras</i>				1						2
<i>Aegires albopunctatus</i>				3						10
<i>Aeolidia papillosa</i>					1					
<i>Anisodoris nobilis</i>	1			3		2				6
<i>Antiopella barbarensis</i>	1									
<i>Archidoris montereyensis</i>	1			2	1	1				
<i>Archidoris odhneri</i>						1				
<i>Cadlina luteomarginata</i>		2				1				
<i>Cadlina modesta</i>		3		2	1	1		1	11	
<i>Coryphella trilineata</i>		1		2						3
<i>Diaphana californica</i>										1
<i>Diaulula sandiegensis</i>	4	2		6	4	3				9
<i>Discodoris heathi</i>	1							1	2	
<i>Doriopsilla albopunctata</i>										4
<i>Doto wara</i>				2						2
<i>Eubranchus rustyus</i>										2
<i>Hermisenda crassicornis</i>			1	1						3
<i>Hopkinsia rosacea</i>					1					
<i>Laila cockerelli</i>	1			3						5
<i>Onchidoris hystericina</i>										1
<i>Pleurobr. calif. dent.</i>						1				
<i>Pleurobranchus strongi</i>								1		
<i>Precuthona divae</i>										1
<i>Rostanga pulchra</i>	1	3	1		1	3	1	1		8
<i>Trinchesia abronia</i>										2
<i>Trinchesia albocrusta</i>										3
<i>Trinchesia lagunae</i>										2
<i>Triopha</i> sp.	1	1			5		2	2	1	
<i>Triopha carpenteri</i>		1		20						7
<i>Triopha maculata</i>				4				1	2	
<i>Tritonia festiva</i>		1			1	1	1	1	7	

more frequent in the summer (June, July and August), when 57.9% (277 specimens) of the total specimens were caught. The winter months of December, January, and February yielded 36.9% (176) of the total. Fifty percent more species (total of 33) were caught during the summer months than during the winter (total of 22).

ODUM (1963: 32) used the ratio of

$$\frac{\text{cumulative number of species}}{\sqrt{\text{individuals counted}}}$$

Table 5

Cumulative totals of specimens collected each month

	Jan	Feb	Apr	May	June	July	Aug	Sep	Dec
<i>Acanthodoris hudsoni</i>						2			
<i>Acanthodoris lutea</i>		1				3	12		22
<i>Acanthodoris nanaimoensis</i>						4			
<i>Acanthodoris rhodoceras</i>					1	2			4
<i>Aegires albopunctatus</i>					3	15	1		1
<i>Aeolidia papillosa</i>									2
<i>Anisodoris nobilis</i>	2	1			3	18			8
<i>Antiopella barbarensis</i>	1								
<i>Archidoris montereyensis</i>	1	1			2	3	5		12
<i>Archidoris odhneri</i>	1						2		
<i>Cadlina flavomaculata</i>									16
<i>Cadlina luteomarginata</i>	1		2			1	9		13
<i>Cadlina modesta</i>	1		4		2	11			1
<i>Coryphella trilineata</i>			1	1	2	3			
<i>Dendronotus frondosus</i>						2			
<i>Diaphana californica</i>						1			
<i>Diaulula sandiegensis</i>	3	4	2		6	9	4		22
<i>Dirona picta</i>						2			
<i>Discodoris heathi</i>			2			5	1		1
<i>Doriopsilla albopunctata</i>						8			
<i>Doto wara</i>					2	2			
<i>Eubranchius rusticus</i>						2			
<i>Hermisenda crassicornis</i>				1	1	3		1	3
<i>Hopkinsia rosacea</i>					2		2		3
<i>Laila cockerelli</i>		1			4	5	2		4
<i>Onchidoris hystrixina</i>						1	1		
<i>Pleurobr. calif. dent.</i>	1								
<i>Pleurobranchus strongi</i>			1				1		
<i>Precuthona divae</i>						1			
<i>Rostanga pulchra</i>	2	4	1	1	1	8	4	1	21
<i>Trinchesia abronia</i>						2			
<i>Trinchesia albocrusta</i>						3			
<i>Trinchesia lagunae</i>						3	1		
<i>Triopha</i> sp.		3	3			1			5
<i>Triopha carpenteri</i>			1		23	32	7		5
<i>Triopha maculata</i>			1		4	7			
<i>Tritonia festiva</i>	1	1	2			7	3		2
Totals:	14	16	20	3	56	166	55	2	146
Grand total:									478
Percentages:	2.9	3.4	4.2	0.6	11.7	34.7	11.5	0.4	30.6

single unit, a comparison can be made of the species diversity by utilizing Odum's diversity index (Table 7). The summer versus winter diversity, measured this way, is 2.0 and 1.7, respectively. This difference is rather small (despite the great difference in absolute number of species), but indicates a slightly greater species diversity for the summer months.

Table 6, showing the percentage each species had of the total specimens collected, indicates a highly fluctuating occurrence of species during each year. When Odum's diversity index is applied to the yearly totals, a much greater difference in diversity results (Table 7) than was found between the summer and winter months. The greatest diversity index ratio occurred in 1970 (2.8) and the least in 1967 (1.5).

Comparisons between each year are deceptive because of small sample sizes and the extreme differences in number of specimens collected. A better picture of the fluctuation of species occurrence results when our 1966 - 1968 collecting period is compared with that of 1969 - 1970 (Table 7). The first period has a much lower diversity index ratio (1.6) than the second period (2.3).

Our conclusion, to be considered in view of the irregularities in our data collection, is twofold: 1) During our 5-year study, the species diversity of opisthobranchs from the open coast of San Mateo County did not fluctuate seasonally each year. The trend, rather, was towards sporadic fluctuations throughout the 5 years, involving possible cycles of periods longer than one year. There was little species diversity difference between the summer and winter months. 2) The greatest absolute abundance of opisthobranch species and specimens occurred during the summer months.

ACKNOWLEDGMENTS

Our work was aided by the patience and concern of our families and friends with whom we live. For this support we are grateful. We also thank those who collected with us on dawn tide trips, rainy afternoons, and sunny days, especially Mr. Scott Williams, Mr. Michael Gosliner, Mr. Todd Wiedemeyer, and Rev. Alberic A. Smith.

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as an index to compare species diversity in the same ecosystem at different times. In this paper, we have considered the intertidal rocky habitat of the open coast of San Mateo County as a basic ecological unit. Using this

Table 6

Total specimens collected each year and relative frequency
of the individual species as shown by percentage of total
number of specimens

	Total specimens						Percentage of total specimens represented by each species					
	1970	1969	1968	1967	1966	Total	1970	1969	1968	1967	1966	Total
<i>Acanthodoris hudsoni</i>	2	0	0	0	0	2	1.6	0	0	0	0	0.4
<i>Acanthodoris lutea</i>	3	2	33	0	0	38	2.4	2.1	23.6	0	0	8.0
<i>Acanthodoris nanaimoensis</i>	3	0	0	0	1	4	2.4	0	0	0	1.0	0.8
<i>Acanthodoris rhodoceras</i>	2	1	4	0	0	7	1.6	1.0	2.9	0	0	1.5
<i>Aegires albopunctatus</i>	10	3	2	0	5	20	8.0	3.1	1.4	0	7.0	4.2
<i>Aeolidia papillosa</i>	0	1	1	0	0	2	0	1.0	0.7	0	0	0.4
<i>Anisodoris nobilis</i>	8	4	6	2	12	32	6.4	4.1	4.3	5.0	16.0	6.8
<i>Antiopella barbarensis</i>	0	1	0	0	0	1	0	1.0	0	0	0	0.2
<i>Archidoris montereyensis</i>	1	5	13	2	3	24	0.8	5.2	9.3	5.0	4.0	5.0
<i>Archidoris odhneri</i>	1	0	0	0	2	3	0.8	0	0	0	3.0	0.6
<i>Cadlina flavomaculata</i>	0	0	15	1	0	16	0	0	10.7	2.0	0	3.4
<i>Cadlina luteomarginata</i>	1	2	16	6	1	26	0.8	2.1	11.4	15.0	1.0	5.5
<i>Cadlina modesta</i>	13	6	0	0	0	19	10.4	6.2	0	0	0	4.0
<i>Coryphella trilineata</i>	3	3	1	0	0	7	2.4	3.1	0.7	0	0	1.5
<i>Dendronotus frondosus</i>	0	0	0	0	2	2	0	0	0	0	3	0.4
<i>Diaphana californica</i>	1	0	0	0	0	1	0.8	0	0	0	0	0.2
<i>Diaulula sandiegensis</i>	12	16	16	6	0	50	9.6	16.5	11.4	15.0	0	10.5
<i>Dirona picta</i>	0	0	0	0	2	2	0	0	0	0	3.0	0.4
<i>Discodoris heathi</i>	3	1	1	0	4	9	2.4	1.0	0.7	0	6.0	1.9
<i>Doriopsilla albopunctata</i>	4	0	0	1	4	9	3.2	0	0	2.0	6.0	1.9
<i>Doto wara</i>	2	2	0	0	0	4	1.6	2.1	0	0	0	0.8
<i>Eubranchus rustyus</i>	2	0	0	0	0	2	1.6	0	0	0	0	0.4
<i>Hermisenda crassicornis</i>	3	2	1	3	0	9	2.4	2.1	0.7	7.0	0	1.9
<i>Hopkinsia rosacea</i>	0	1	1	3	2	7	0	1.0	0.7	7.0	3.0	1.5
<i>Laila cockerelli</i>	5	4	6	0	1	16	4.0	4.1	4.3	0	1.0	3.4
<i>Onchidoris hystrixina</i>	1	0	1	0	0	2	0.8	0	0.7	0	0	0.4
<i>Pleurobr. calif. dent.</i>	1	0	0	0	0	1	0.8	0	0	0	0	0.2
<i>Pleurobranchus strongi</i>	1	0	0	0	1	2	0.8	0	0	0	1.0	0.4
<i>Precuthona divae</i>	1	0	0	0	0	1	0.8	0	0	0	0	0.2
<i>Rostanga pulchra</i>	10	9	8	16	0	43	8.0	9.3	5.7	40.0	0	9.0
<i>Trinchesia abronia</i>	2	0	0	0	0	2	1.6	0	0	0	0	0.4
<i>Trinchesia albocrusta</i>	3	0	0	0	0	3	2.4	0	0	0	0	0.6
<i>Trinchesia lagunae</i>	2	0	1	0	1	4	1.6	0	0.7	0	1.0	0.8
<i>Triopha</i> sp.	5	7	0	0	0	12	4.0	7.2	0	0	0	2.5
<i>Triopha carpenteri</i>	7	21	11	1	28	68	5.6	21.6	7.9	2.0	37.0	14.0
<i>Triopha maculata</i>	3	4	0	0	5	12	2.4	4.1	0	0	7.0	2.5
<i>Tritonia festiva</i>	10	2	3	0	1	16	8.0	2.1	2.2	0	1.0	3.4
Total specimens:	125	97	140	41	75	478						

Table 7

Diversity Index Ratio:

for each year, cumulative for all years, for each half of the collecting period, and for summer and winter months

	1970	1969	1968	1967	1966	Total
Total specimens	125	97	140	41	75	478
Square root of total						
number of specimens	11.2	9.8	11.8	6.4	8.6	21.9
Number of species	31	21	19	10	17	37
Odum's index number	2.8	2.1	1.6	1.5	2.0	1.7

	1970-69	1968-66	Summer	Winter
Total specimens	222	256	277	176
Square root of total				
number of specimens	14.9	16	16.7	13.3
Number of species	34	26	33	22
Odum's index number	2.3	1.6	2.0	1.7

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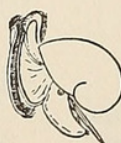
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