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Snailfishes of the central California coast: video, photographic and morphological observations

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Video and photographic images of snailfishes (Liparidae) collected by the Monterey Bay Aquarium Research Institute, augmented by specimens collected simultaneously, were analysed. Nine species in five genera were identified, including *Careproctus melanurus*, *Careproctus ovigerus*, *Careproctus longifilis*, *Careproctus gilberti*, *Careproctus filamentosus*, *Osteodiscus cascadiae*, *Nectoliparis pelagicus*, *Paraliparis dactylosus* and *Rhinoliparis barbulifer*. Voucher specimens were collected of all except *C. melanurus, C. gilberti* and *C. filamentosus*. In addition, individuals of the *Paraliparis* '*rosaceus*' species group were abundant but could not be identified to species. Many liparids were identified only to family, but an individual of a very distinctive unknown species, presumably undescribed, was videotaped. Relative abundance of *C. melanurus* was estimated, and several *in situ* snailfish behaviours are described for the first time.

Key words: behaviour; Liparidae; morphology; snailfishes; video.

INTRODUCTION

The Monterey Bay Aquarium Research Institute (MBARI) was founded in 1987 as a means of advancing undersea research through an equal partnership between research scientists and engineers. Subsequently it has become very well known for its innovative use of advanced visual sampling technologies *via* remotely operated vehicles (ROVs). During the past 15 years, these vehicles have worked primarily in Monterey Canyon, California, U.S.A. MBARI scientists have collected thousands of hours of video and still photographs, including images of a wide variety of pelagic and benthic organisms, many of them rare or never before seen alive. These visual records form a valuable resource that has been underutilized. Some authors have used it to study delicate invertebrates not easily studied from trawl capture (Robison *et al.*, 1998, 2005;

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Silguero & Robison, 2000; Raskoff, 2002), but only a few incidentally recorded fishes from the dives have been studied (Drazen *et al.*, 2003). Unlike some other studies using visual records from ROVs or submersibles (Pearcy *et al.*, 1990; Stein *et al.*, 1992, 2005; Felley & Vecchione, 1995), these data were collected incidentally during other studies and are unquantifiable. They do not represent new methods of collecting data and do not illustrate data collection problems.

The snailfishes (Liparidae) are one of the benthic fish families commonly seen in Monterey Canyon. The family has over 350 described species in *c.* 30 genera, many of which are rare. Twenty-five of these species have been recorded from Californian waters (Chernova *et al.*, 2004), but considering the species known from Oregon but not recorded from California (Chernova *et al.*, 2004), the true number occurring in the region is probably much higher. With few exceptions, little is known of their biology and behaviour; none have been studied *in situ*. As of August 2001, MBARI videos included 421 occurrences of liparids from 158 ROV dives. Although many of these individuals could be identified only to family, individuals of nine species were identified: *Careproctus melanurus* Gilbert 1892, *Careproctus ovigerus* (Gilbert 1896), *Careproctus longifilis* Garman 1892, *Careproctus gilberti* Burke 1912, *Careproctus filamentosus* Stein 1978, *Osteodiscus cascadiae* Stein 1978, *Nectoliparis pelagicus* Gilbert & Burke 1912, *Paraliparis dactylosus* Gilbert 1896 and *Rhinoliparis barbulifer* Gilbert 1896. Voucher specimens were collected of all except *C. melanurus, C. gilberti* and *C. filamentosus*. In addition, individuals of the *Paraliparis* '*rosaceus*' Gilbert 1890 species group (Stein, 1978) were seen. These video and photographic data provide not only information on behaviour, appearance *in situ* and habitat, but also on frequency of occurrence, abundance, depth distribution and reproduction. Because all observations were obtained incidental to other studies, no experimentation or repetitive sampling was possible.

MATERIALS AND METHODS

MBARI's video annotation reference system (VARS) database includes annotations for >16 000 video-tapes (*c.* 12 000 h) accumulated over 15 years, and is uniquely managed as a centralized institutional resource. The database contains 1·6 million individual records of the biological, chemical, geological and physical aspects primarily of the Monterey submarine canyon but also other areas including the Pacific Northwest, southern California basins, central California seamounts, northern California, Oregon, Hawaii and the Gulf of California. Each annotation is associated with navigation information and physical variables such as water temperature, salinity, depth and dissolved oxygen. The VARS was developed by MBARI engineers to facilitate the creation, storage and retrieval of video annotations, and includes >3000 biological, geological and technical search terms organized in a hierarchical system to allow for consistent and rapid classification, description and complex querying of objects observed on the ROV video. System documentation can be found at http://www.mbari.org/vars/.

Video footage used in this study was recorded by the MBARI ROVs *Tiburon* (T) and *Ventana* (V), between 8 September 1989 and 26 August 2001. *Tiburon* is a unique ROV developed at MBARI for use with the small water-plane area twin hull vessel, RV *Western Flyer*, and operable to depths of 4000 m. *Tiburon* is equipped with metallogen metal halide arc lamp lighting, sensors to measure conductivity (salinity), temperature, depth and oxygen, imaging sonar and a GIS navigation system (Newman & Robison, 1993). All recordings came from a high-resolution colour video camera (three-chip Panasonic WVE550) with precision pan/tilt/zoom capability. *Ventana* is operated from the RV *Point Lobos*, a conventional-hulled vessel, and is similarly equipped except that its camera is a high-resolution Sony DXC-3000, three-chip colour video camera with a Fujinon 5·5-44 mm zoom lens, mounted on a pan and tilt unit (in September 1999 *Ventana*'s camera was upgraded to a Sony HDC-750A). The *Ventana* has a 2000 m depth rating.

Video was recorded onto Sony Analog Betacam tape from 1989 until 1997 and on Sony Digital Betacam from 1998 to the present. All dive tapes have been reviewed by MBARI video technicians (biologists), who identified taxa to the lowest possible taxonomic level and entered the observations in the database. To maximize the number of liparid records and to minimize misidentifications of non-liparids identified as liparids, all their observations of similar looking families were reviewed by the authors, specifically liparids, zoarcids and ophidiids. Fishes seen were identified to the lowest possible taxon: unidentified liparid, genus or species. Depth ranges for each species are based only on the authors' observations. Individual ROV dives often sampled a variety of depths, sometimes over a broad range of hundreds of metres. These data were non-quantitative except for observations of *C. melanurus* made during 31 quantitative video transects, and no attempt should be made to use them to determine relative or absolute abundances of the different taxa.

Most liparids are difficult to identify, even if specimens are in hand (Stein, 1978). Even at the generic level it can be extremely difficult to distinguish among them solely on photographic evidence. Therefore, identification was considered questionable if there was any uncertainty. The numbers of individuals observed per species are minima, and likely to be greater than the counts.

Although the MBARI video collection includes thousands of hours of video from various habitats within the Monterey Canyon, these data cannot be used to assess habitat associations because the distribution of the sampling across habitat and substratum types is unavailable. Most video observations were made during investigations that were not intended for habitat classification and often not even for biological investigation. Because the dive time spent in various habitat types was not determined during video annotation, quantitative information on where liparids were not observed is unavailable. It is also not possible to derive a distribution of all observations. Furthermore, liparid observations in the data set are relatively few, precluding robust analyses. Therefore, significant correlations between occurrence and habitat type cannot be tested statistically, and observations are limited to per cent of occurrence on specific habitats.

Records were made of whether individuals were swimming or not, position on the substratum, orientation to currents, proximity to crabs (if present), reaction to ROV, body attitude of the fish (*e.g.* head up and down), any other behaviours seen, nearness to the bottom, primary substratum type (mud, sand, pebble, cobbles, boulders, flat rock, and rock ridges and walls), bottom relief (flat, low, high, and wall and cliff) and associated fauna.

Thirty-one quantitative transects between 1991 and 2003 were videotaped and analysed at upper slope and mid-slope depths (200–1500 m) to assess the abundance, distribution and changes in invertebrate megafauna and demersal fishes. These transect results were used to estimate the abundance of *C. melanurus*.

MBARI collections also include some voucher specimens collected with a 'suction' sampling device. All these were identified; in many cases, they were also videotaped before and during collection. The specimens are deposited at MBARI.

RESULTS

Records of 421 sightings from 158 ROV dives were verified (Table I). The following species were identified with certainty: *C. melanurus*, *C. longifilis*, *C. ovigerus*, *O. cascadiae*, *N. pelagicus*, *P. dactylosus* and *R. barbulifer*. Specimens were collected of all but *C. melanurus* (Table II). All other identifications were considered tentative. Two more species, *C. filamentosus* and *C. gilberti*, were identified solely from visual records, and although they are morphologically distinct, in the absence of specimens their identifications cannot be absolutely certain. The *P.* '*rosaceus*' group of species includes *P. rosaceus*, *Paraliparis paucidens* Stein

TABLE I. Liparid taxa identified from MBARI video-tapes, number of observations by taxon, and minimum and maximum depths of observations. Vouchers (Table II) were collected by slurp gun after videotaping

Taxon	Observations	Voucher	Minimum depth (m)	Maximum depth (m)
Liparidae	151		75	3609
Careproctus sp.	9		778	2327
Careproctus filamentosus	1	No	3033	
Careproctus '*gilberti*'	2	No	632	677
Careproctus longifilis	9	Yes (4)	2289	3499
Careproctus melanurus	168	No	149	1280
Careproctus melanurus?	38	No	292	2453
Careproctus ovigerus (pink)	12	Yes (1)	922	2062
Careproctus ovigerus (white)	6	No	2064	3105
Nectoliparis pelagicus	2	Yes (2)	419	541
Osteodiscus cascadiae	8	Yes (4)	1348	3500
Paraliparis dactylosus	1	Yes (1)	855	
Paraliparis '*rosaceus*'	11	No	1333	3503
Paraliparis '*megalopus*'	1	No	1586	
Rhinoliparis barbulifer	1	Yes (1)	935	
Total	421	13		

1978 and *Paraliparis nassarum* Stein & Fitch 1984, which cannot be distinguished from one another without having specimens in hand and therefore will be referred to below as *P.* '*rosaceus*'. Identification of *Paraliparis megalopus* Stein 1978 is also tentative and it will be referred to similarly as *P.* '*megalopus*'. Of

TABLE II. Voucher specimens collected by MBARI ROVs. Samples of *Nectoliparis pelagicus* were collected prior to the designation of dive numbers and are catalogued by dive date only

Species	L_T/L_S (mm)	ROV dive tape	Time (hours)	Date
Careproctus longifilis	189/164	T239#8	080653	16/11/00
Careproctus longifilis	199/176	T365#7	072803	03/10/01
Careproctus longifilis	138/122	T395#7	072850	20/02/02
Careproctus longifilis	92/81	T395#7	071400	20/02/02
Careproctus ovigerus	166/145	T834#7	064756	22/03/05
Nectoliparis pelagicus	50/47	Tape 10	031819	13/03/90
Nectoliparis pelagicus	48/46	Tape 5	020549	24/10/91
Osteodiscus cascadiae	50/43	T438#9	084551	12/06/02
Osteodiscus cascadiae	86/75	T394#7	072525	19/02/02
Osteodiscus cascadiae	? / ?	T423#9	091916	09/05/02
Osteodiscus ?cascadiae	55/49	T132#5	045750	15/04/00
Osteodiscus ?cascadiae	64/56	T777#5	042340	06/01/05
Paraliparis dactylosus	? /100	T424#4	035740	10/05/02
Rhinoliparis barbulifer	69/63	T424#4	031625	10/05/02

L_S, standard length; L_T, total length; T, ROV *Tiburon*.

the individuals identified as liparids, 151 of them could not be identified to a level below family. The majority of snailfishes counted were *C. melanurus* (168–206 individuals seen, depending on whether 38 '*melanurus*' of questionable identity are included); the second most abundant species was *C. ovigerus* (18 individuals) (Table I).

Careproctus melanurus was the only liparid seen during quantitative transects, probably because they were made at upper slope depths where there are comparatively few liparid species. This species does not seem to avoid the ROV, so it was possible to estimate its density.

Of the many unidentifiable individuals, some were easily distinguishable from similar species, but were not close enough or in view long enough to allow detailed descriptions. These have not been included as individual descriptions here, because they cannot be identified with confidence if viewed again. They are included in the category 'unidentified liparids'.

The data show that species distributions were related to depth (Fig. 1 and Table I), habitat type (Table III) and oxygen concentration (Fig. 2). The habitat in which liparids occurred is shown in Table III. Substratum categories included boulder, cobble, flat rock, mud, ridge and wall, pebble, and midwater. Midwater occurrences of snailfishes were unusual in the MBARI video records, with only 15 individuals observed $\geq$10 m above the bottom (Fig. 3). Most snailfishes (358 of 421 observations, 85%) were near the bottom (Fig. 3), usually <0·5 m above it, and another 48 specimens were between 0·5 and 3·0 m up. Most fishes were observed swimming; only 53 (13%) were resting on the seafloor or hovering in the water column.

SPECIES ACCOUNTS

Careproctus melanurus *149–1280 m (n = 168) [Fig. 4(a)]*

Careproctus melanurus is a common benthic fish at midslope and upper slope depths in Monterey Canyon (Fig. 5). Some possible sightings were deeper (1480–2084 m) but those identifications were only tentative. Distinctive characters in the visual records include a relatively thick pink body with black-edged dorsal

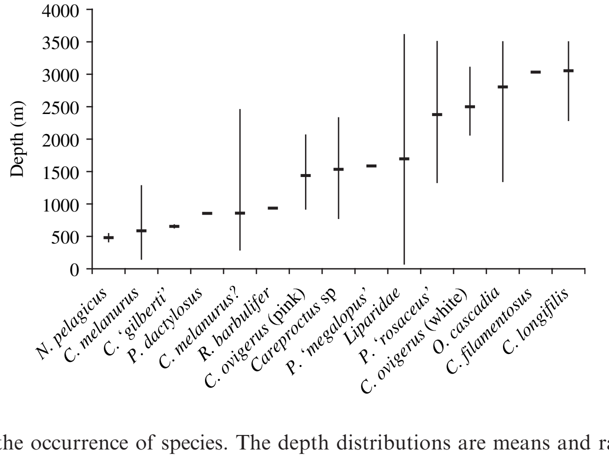

FIG. 1. Depth and the occurrence of species. The depth distributions are means and range.

TABLE III. Frequencies of occurrence of liparids with primary substratum types. Total number of observations for each group is given on the right and proportions of all observations in various habitat types are shown at the bottom of the table

Species	Mud (%)	Sand (%)	Cobbles (%)	Boulders (%)	Flat rock (%)	Ridges/wall (%)	Midwater (%)	Number of observations
Liparidae	66·7		3·4	12·2		12·2	6·8	149
Careproctus sp.	22·2		22·2	33·3	11·1	11·1		9
C. filamentosus	100·0							1
C. gilberti						50·0	50·0	2
C. longifilis	100·0							9
C. melanurus	97·6	0·6			0·6	0·6	0·6	168
C. melanurus?	88·6		2·9	5·7	2·9			35
C. ovigerus pink	8·3		8·3	33·3		50·0		12
C. ovigerus white	66·7			16·7		16·7		6
N. pelagicus							100·0	2
O. cascadiae	100·0							8
P. dactylosus							100·0	1
P. 'rosaceus'	63·6			18·2	9·1	9·1		11
P. megalopus				100·0				1
Paraliparis sp. BBC							100·0	1
R. barbulifer							100·0	1
Total	77·9	0·2	2·2	7·7	1·0	7·0	3·8	416

and anal fins and a black caudal fin. Although the videos do not represent a random sample, *C. melanurus* was typically seen on a soft bottom (mud or sandy silt), with a few occurring on gentle slopes over muddy cobbles and rock ledges. This species occurred 97·6% of the time on muddy bottoms (Table III), and occasionally on partially rocky bottoms and once as much as 100 m above the bottom.

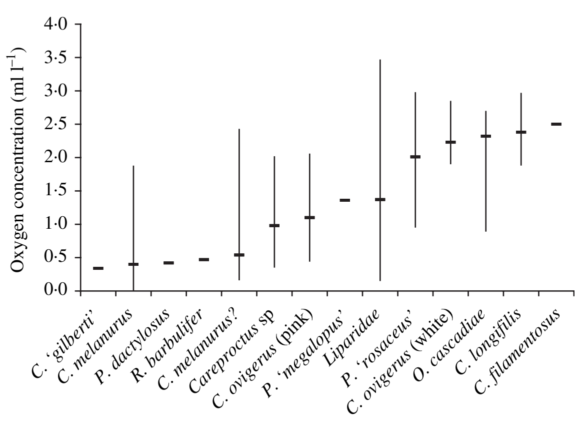

FIG. 2. Oxygen concentration and the occurrence of species. The oxygen values are means and range. There are no data for *N. pelagicus*.

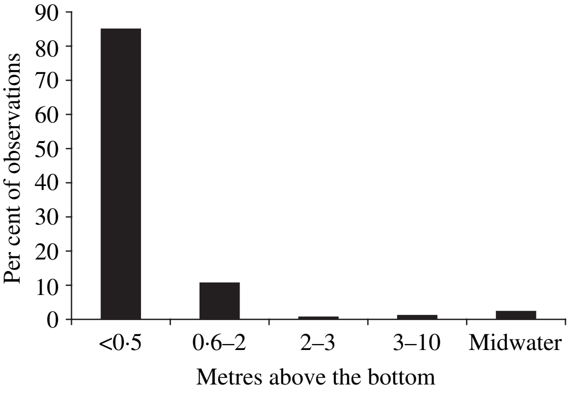

FIG. 3. Percentage of observations as a function of distance from the bottom. Animals considered midwater were seen in the water column at least 25 m above the bottom. Exact distances above the bottom were difficult to determine due to the steep topography in some areas.

Careproctus melanurus was usually observed hovering horizontally just above bottom or up to a metre above it, often with its head inclined slightly downwards. When off the bottom, it swam very slowly (trunk and tail just rippling) holding its direction facing into the current, sometimes drifting slowly backwards. When hovering near the bottom, it used its pectoral fins to maintain position, frequently with the elongate lower lobe rays erect and pointing downwards. Videos showed it was neutrally buoyant despite lacking a swimbladder. Occasionally it was observed directly on the bottom, when it was often curled in a 'U' shape, with its tail towards the head, unlike zoarcids, in which

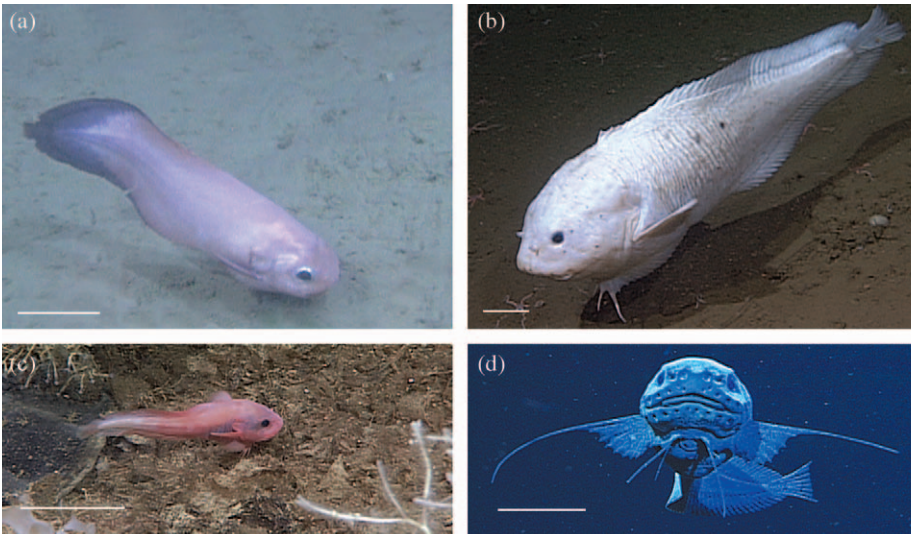

FIG. 4. (a) *Careproctus melanurus*. Dive V922, 36°43′ N; 122°03′ W, 28 July 1995, 995 m. (b) *Careproctus ovigerus* adult. Dive T243, 36°34′ N; 122°18′ W, 30 November 2000, 2115·8 m. (c) *Careproctus ovigerus* juvenile. Dive T425, 35°44′ N; 122°44′ W, 19 May 2002, 1324 m. (d) *Careproctus longifilis*. Dive T239, 36°35′ N; 122°31′ W, 16 November 2000, 3002 m. Scale bars 5 cm.

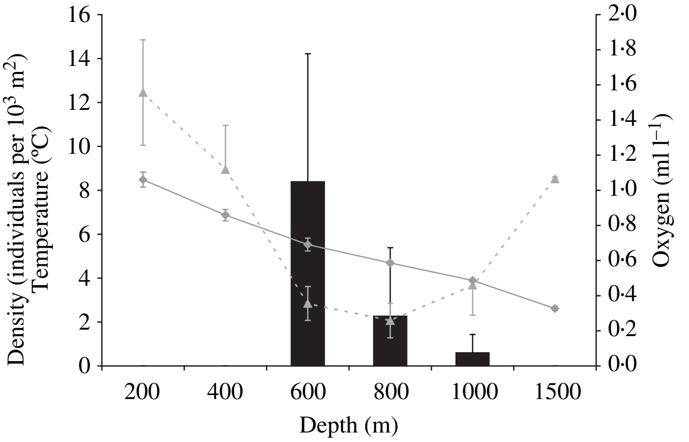

FIG. 5. The mean ± S.D. density of *C. melanurus* by depth (■), temperature (-◆-) and oxygen concentrations (-▲-) from 31 quantitative video transects in Monterey Bay.

the body is actually coiled (unpubl. obs.). Some fish displayed obvious avoidance behaviours, rapidly changing direction and swimming away from the vehicle or off to the side out of the field of view but only when the ROV approached to within *c.* 1 m. One individual swam directly down into the bottom and apparently stayed there, and a few seemed to be attracted to the ROV or its activities. One fish was without a tail, which appeared to have been bitten off.

The most interesting single observation made was of two liparids, probably this species, in a kelp mass caught on an instrument being retrieved by the ROV after deployment for several days on the seafloor. At first, the fish were not visible, but as the ROV pulled at the mass and tore pieces of it away in an attempt to free the instrument, two individuals could be seen (ROV dive V2011, 25 June 2001, 1279 m). One fish remained in the kelp until the manipulator arm completely freed the instrument from the algae (>1·5 min). Although eggs were not seen, this behaviour was suggestive of egg or nest protection. Liparids are known to lay eggs attached to hydroids (Able, 1976) and algae (Detwyler, 1963), to sexually parasitize crabs (Somerton & Donaldson, 1998), and to use scallops for shelter (Able, 1976), therefore this is not an unexpected observation. It is the first time, however, that such an observation has been made *in situ*.

Careproctus melanurus was the most abundant liparid on the upper slope, and its occurrence was depth related (Fig. 5); (a one-way ANOVA, d.f. = 25, 5, $P < 0{\cdot}001$). At 600 m, abundance was *c.* eight individuals per 10^3 m^2; at 800 m, it was *c.* two per 10^3 m^2 and at 1000 m, *c.* one per 10^3 m^2. Above and below that depth, *C. melanurus* was uncommon. The depth of highest abundance was coincidental with the depth of lowest oxygen values in the oxygen minimum zone.

Careproctus ovigerus *922–3105 m (n = 18) [Fig. 4(b), (c)]*

This species is rare in collections; as far as is known, it has been collected <10 times, including the holotype. It seems to be relatively abundant, however, in Monterey Canyon. It is very distinctive because it is large, heavy-bodied with well-developed fins, and the adults are white. Large adults and large juveniles or smaller adults were seen. The former were pale or cream-coloured and often had wrinkled skin, but the latter were pink and smooth. A small individual (145 mm standard length, L_S) was collected during ROV dive T834, allowing verification of identification.

The two size groups seemed to have different depth distributions: smaller pink individuals occurred from 922 to 2062 m; larger white ones from 2248 to 3105 m. Individuals were usually seen on or near rock ledges on bottoms with significant relief. Several were near cold seeps. When the ventral part of the pectoral fin could be seen, its rays were usually extended towards the substratum.

Two individuals were observed 'scratching' themselves on the bottom. A large fish seen at 2694 m depth had significant amounts of mud on its back and was recorded rolling over and rubbing its back on the bottom. This individual was distinctive because it had a split caudal fin. The second fish swam slowly away from the camera and rolled to 'scratch' its right side on the bottom; mud clung to it. One individual was observed with parasites (probably copepods) on its pectoral fins and another had two parasites on its left side. Several individuals were seen attached to rocks: one swam around and along some rock ledges, then rolled sideways and attached itself to the side of a ledge, another attached upside down under a ledge, and a third was attached to the side of a ledge. One fish was blinded by the ROV: when it swam away, it ran directly into a rock.

Careproctus longifilis *2289–3499 m (n = 9) [Fig. 4(d)]*

Seen in Monterey Canyon and on Juan de Fuca and President Jackson Seamount, *C. longifilis* is unmistakable because its dorsal-most pectoral fin ray is extremely elongated to almost twice its head length. Individuals were usually found swimming slowly horizontally, a few metres above the bottom. The pectoral fin rays were almost always (seven of nine individuals) extended; the upper lobe rays were orthogonal to the body and the lower rays were extended ventrally while swimming by longitudinal undulation. When swimming, the fish's skin made obvious wrinkles on the sides of the body. One specimen, collected as a voucher, had a copepod in the left gill opening. The individuals observed swam lethargically; one swam lethargically even while trying to avoid being collected. One of the vouchers is the largest known specimen (199 mm total length, L_T, 176 mm L_S).

Nectoliparis pelagicus *419–541 m (n = 2) [Fig. 6(a), (b)]*

This is a small epi- and mesopelagic species that is relatively common in Monterey Bay (Stein, 1978). Only two individuals were observed. This small species is probably commonly overlooked in the videos and thus not recorded, or ignored by ROV pilots because of confusion with the zoarcid *Lycodapus mandibularis* Gilbert 1912, which occurs at similar depths. *Nectoliparis pelagicus* curls like a zoarcid in midwater, and when disturbed, consistently swims downwards.

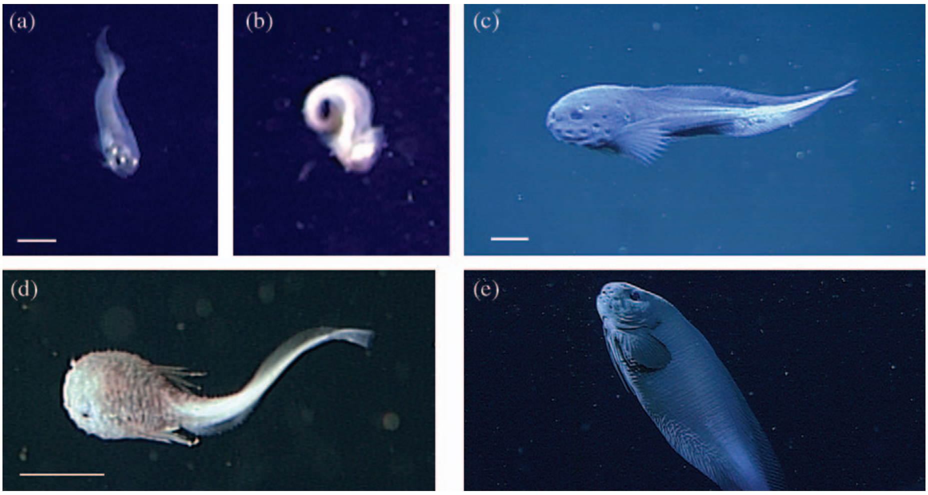

FIG. 6. (a) *Nectoliparis pelagicus* swimming. Dive V3-13-90, 36°42′ N; 122°02′ W, 13 March 1990, 418·5 m. (b) Same individual curled in midwater. (c) *Osteodiscus cascadiae*. Smooth head, Dive T394, 36°34′ N; 122°32′ W, 19 February 2002, 2991·5 m. (d) *Osteodiscus cascadiae*. Bumpy head, Dive T438, 36°35′ N; 122°30′ W, 12 June 2002, 2988 m. (e) *Careproctus filamentosus*. Dive T363, 36°34′ N; 122°31′ W, 1 October 2001, 3033 m. Scale bars 1 cm.

Osteodiscus cascadiae *1348–3500 m (n = 8) [Fig. 6(c), (d)]*

Although it is easily identified from specimens owing to its distinctive disc, *O. cascadiae* is small and can not be positively identified from photographs or video footage. This species looks similar to a small *C. longifilis* without the elongate first pectoral fin rays. Many of the unidentified snailfishes were small individuals with globular heads and slender bodies and may have been *Osteodiscus*. Five voucher specimens were collected (Table II).

There may be another, previously unknown species of *Osteodiscus* present in Monterey waters. Two of the five voucher specimens (Table II) have heads and bodies covered with small, closely set tubercles [Fig. 6(d)], and differ in some respects from all other *O. cascadiae* examined. The individual in better condition (56 mm L_S), collected on *Tiburon* dive T423, was swimming horizontally and slowly 1–2 m above a mud bottom, but it swam up into the water column when chased by the ROV. It held its lower pectoral fin rays erect and down, and the video clearly shows that in life its head was closely covered by many small bumps. Another specimen (49 mm L_S) was collected on *Tiburon* dive 132, and some similar (uncollected) individuals were seen on other dives. Three voucher specimens of 'normal' *O. cascadiae* were also collected.

Careproctus filamentosus *3033 m (n = 1) [Fig. 6(e)]*

The video for this fish was close and of good quality, allowing its identification on the basis of the very long lower pectoral fin lobe rays, the size of the mouth and general appearance. It seemed to have large patches of mud on the side of the head and along the midline of the body. The skin was evenly wrinkled, although the trunk was not flexed; the wrinkles extended from the base of the dorsal fin to that of the anal fin. The fish swam slowly and did not avoid the vehicle.

Careproctus gilberti *632–677 m (n = 2) [Fig. 7(a)]*

Two individuals were observed, both with the distinctive eye having the dorsal half silver and the ventral half black. In addition, the video clearly shows the silver branchial cavity and peritoneum and very long lower pectoral fin rays. A video of the individual seen during ROV dive V1222 was excellent and lasted *c.* 2·5 min. The *C. gilberti* seen in ROV dive V1222 was seen close to a high relief rock wall near a cold seep community, and was resting in a scooped out hollow in muddy sediment. Its very long lower pectoral fin rays were erect, touching the substratum and extending into the hole, almost as though it was probing, and the fish was oriented into the current. The individual from ROV dive V1440 was similar in appearance, and was initially curled up well above the bottom (*e.g.* in midwater) but then swam across the front of the ROV. It may have been drifting in the slow current, and adopted various attitudes, *e.g.* head up, down and body horizontal.

Paraliparis dactylosus *855 m (n = 1) [Fig. 7(b)]*

Only one individual was seen, and it was captured (Table I). This species was redescribed by Stein (1978) and the new specimen does not differ in any significant way from the description.

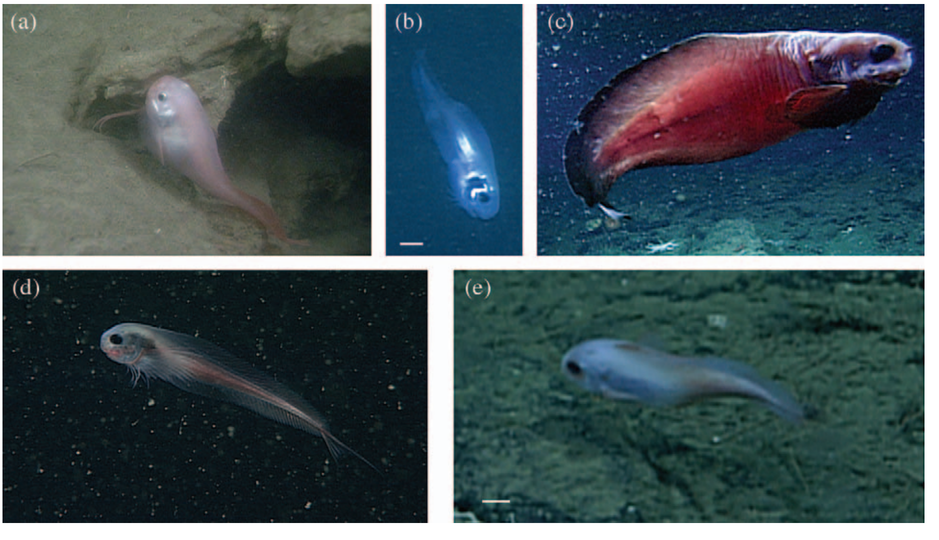

FIG. 7. (a): *Careproctus gilberti*. Dive V1222, 36°46′ N; 122°03′ W, 24 February 1997, 677 m. (b) *Paraliparis dactylosus*. Dive T424, 36°47′ N; 122°01′ W, 10 May 2002, 855 m. (c) *Paraliparis* '*rosaceus* group'. Dive T448, 40°22′ N; 125°13′ W, 22 July 2002, 1578 m. (d)? *Paraliparis* sp. Dive T9-29-02, 36°42′ N; 122°07′ W, 29 September 2002, 1837 m. (e)? *Careproctus* sp. Dive T448, 40°22′ N; 125°13′ W, 22 July 2002, 589 m. Scale bars 1 cm.

Paraliparis 'megalopus' *1586 m (n = 1)*

A single individual was identified, in an area of high relief (boulders and cobbles). Although the photograph is not very good, the fish had a large eye and was pink with a black peritoneum. It was initially on the bottom, then swam up into the water column and straight down into a rock, then into a crevice where it remained. It was similar to *P. megalopus* in having a large eye and similar proportions, but its body colour differed from that of *P. megalopus,* which is tan or dark brown with a blackish head. It is possible, but unlikely, that colour changes from death and preservation account for this difference.

Paraliparis 'rosaceus *group' 1333–3503 m (n = 11) [Fig. 7(c)]*

Eleven individuals of the *P.* '*rosaceus* group' were seen. At least two species of this group of very similar species are known to occur off central California: *P. rosaceus* and *P. nassarum*. To the north, there is another similar species, *P. paucidens*, which has not been recorded south of Oregon. These cannot presently be distinguished without specimens in hand; they differ primarily in fin ray counts and dentition, although *P. rosaceus* probably reaches a significantly greater maximum size. Individuals from Monterey were brown to pinkish or black with black peritoneums and very short heads. One individual was sheltering in a hole in carbonate rock, another was near the carcass of a dead seal being eaten by a variety of invertebrates at 1681 m, and one was apparently attracted to the ROV.

Rhinoliparis barbulifer *935 m (n = 1)*

Only one individual was seen. It was at a depth of 935 m in midwater, 65 m above the bottom in Soquel Canyon, a northern offshoot of the main Monterey Canyon axis. This individual was swimming head down at an angle of *c*. 30 degrees, with the lower pectoral fin rays erect. Captured as a voucher specimen, it was retrieved alive from depth, and maintained in an aquarium for 25 days during which time it swam but did not eat.

? Paraliparis *sp. possibly new 1837 m (n = 1) [Fig. 7(d)]*

This species is presently unidentifiable and possibly undescribed; it was seen *c*. 25 m off the bottom. The individual was distinguished by having the dorsal-most two pectoral fin rays free almost to the base, and an extremely elongate upper caudal fin ray. It was pale pink with a black peritoneum. No known liparid has been described with these characters (in fact, no species is known with an elongate caudal ray). It may have been described but damaged during collection, resulting in an incomplete description.

Other unidentified snailfishes [Figs 7(e) and 8]

Two distinctly different but unidentified individuals, apparently *Careproctus* or *Paraliparis* sp. were observed. One was a grey fish with a large eye close to the dorsal profile of the head and with pectoral fins low on the side of

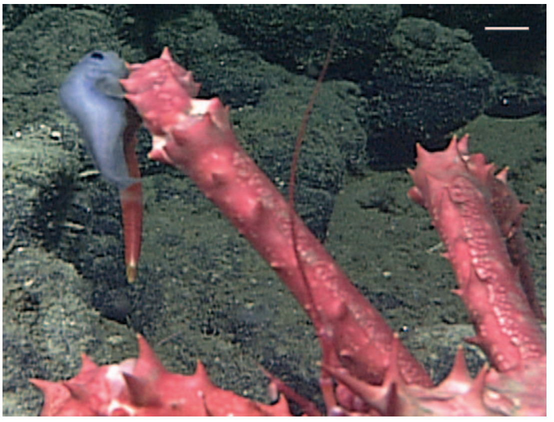

FIG. 8. ? *Careproctus* sp. on *Paralomis* sp. Dive T670, 33°59′ N, 121°06′ W, 7 May 2004, 1432 m. Scale bar 1 cm.

the body [Fig. 7(e)]. It was similar to that shown in Fig. 8 attached to the leg of a *Paralomis* crab. If the two are the same, it must be a *Careproctus*. Another fish similar to *C. melanurus* but lacking a pink body was seen, although it may possibly have had a black tail. It was drifting, head up, tail curled. Finally, as mentioned above, many small snailfishes were seen but could not be identified.

DISCUSSION

Identifications of many of the individuals observed during this study, but not collected, are provisional. In addition to the obvious reasons (*e.g.* lack of detail, inability to make counts and measurements or determine qualitative characters) lighting is a significant factor when making video observations. Apparent colour of a fish can vary owing to selective absorption of light spectra depending on distance from the camera. For instance, pink individuals close to the camera can appear white when farther away. Although attempts were made to adjust the observations by taking into account the distance of the individual from the camera, the true colour often remained uncertain. In addition, most of these species have never been seen alive before, and their colour and appearance in life is distinctly different than after preservation.

Despite identification difficulties, nine species were positively identified and several others were tentatively identified, including most of the species previously noted in the literature from Monterey Bay by Cailliet *et al.* (1999). They listed *Acantholiparis* sp., *C. melanurus*, *C. ovigerus* (as *Careproctus ovigerum)* and *P. rosaceus* as liparid species collected in beam trawls off Monterey. The latter three, but not *Acantholiparis* sp., were identified from the MBARI videos. This is not unexpected because *Acantholiparis* is a small to very small genus (<70 mm L_S) that would be very difficult to identify using a video camera located a metre above the bottom. Quite a few small unidentifiable liparids of similar size were seen, and it is reasonable to assume that some of them were probably *Acantholiparis* sp.

The distributions of the liparids examined in this study were related to depth, habitat type and oxygen concentration. Stein (1978) and Pearcy *et al.* (1982)

found similar depth differences among liparid species off Oregon. The most common habitats of snailfishes in Monterey Canyon were muddy bottoms (Table III), although *C. ovigerus* adults and particularly juveniles (pink *C. ovigerus*) were seen most often near rock ledges and among boulders (Table III). *Careproctus ovigerus* has been considered rare. There are few published records of its capture (Gilbert, 1896; Stein, 1978; Cailliet *et al.*, 1999), although several more unpublished records are known (K. Sendall, pers. comm.). Yet, they were the second most commonly recorded species in the video footage. Their rarity is probably due to their preferred habitat (apparently rock ridges) being difficult to sample. It was also interesting to note the deeper occurrence of adults. This pattern suggests an ontogenetic migration to greater depths, as has been found in a diverse group of other slope-dwelling fishes (Polloni *et al.*, 1979; Stein & Pearcy, 1982; Jacobson & Hunter, 1993; Jacobson & Vetter, 1996).

The oxygen minimum layer (OML) may affect occurrence. As noted above, *C. melanurus* were most abundant at the depth of lowest oxygen concentration (Fig. 5) and were also observed at an average oxygen concentration of 0·40 ml l^{-1} (Fig. 2). The species is also known from much shallower depths where the O_2 concentration is significantly higher, suggesting that it tolerates a wide O_2 concentration range. Unlike *C. melanurus*, most other species were not found at O_2 concentrations *c.* <0·5 ml l^{-1}. Two *C. gilberti*, one *P. dactylosus* and one *R. barbulifer* were exceptions. Although the data were limited and the sample collection was not designed to provide complete or equitable geographic and depth coverage, this investigation suggests that most of the other liparid species may actively avoid or do not occur in the OML (Fig. 2).

The fishes usually swam slowly and lethargically close to the bottom either holding position oriented into the current or undulating to move forward. It was surprising that a group of fishes, a majority having a ventral 'sucking' disc and seemingly adapted for a strictly benthic existence, were rarely observed actually resting on the bottom. It should be noted, however, that members of the genus *Careproctus* are well known for attaching to crabs, an apparently common behaviour probably related to sexual parasitism of the crabs (Somerton & Donaldson, 1998).

Observations of liparids in midwater were unusual. Although very few *N. pelagicus* were found, it is often captured by midwater trawls in Monterey Bay and is a well-known nearshore pelagic species (Stein, 1978). It may have been overlooked by ROV pilots who have primarily focused on gelatinous zooplankton. It is also possible that its behaviour of curling led pilots to mistake it for midwater zoarcids such as *L. mandibularis* and *Melanostigma pammelas* Gilbert 1896, that also curl when startled (Robison, 1999) and therefore ignore it. *Paraliparis dactylosus* is also pelagic. The extent to which *R. barbulifer* is pelagic has been discussed (Kido & Kitagawa, 1986), and it has been suggested to be benthic, benthopelagic and pelagic. The present data suggest it is benthopelagic; it was recorded at > 100 m above bottom. *Careproctus longifilis* may also be benthopelagic; it was found 2–10 m above the seafloor four out of the nine times it was observed.

One of the most interesting discoveries from the videos is the use of the ventral 'sucking' disc. Arita (1967) attempted to determine whether the disc could function at great depths or was simply a relict organ as evidenced by its reduced size in most deepwater forms. He concluded that it was functional, and that the reduced size of the disc in the deepwater forms was the result of reduced current and increased efficiency owing to the greater ambient pressure requiring less disc area to achieve attachment. The present video footage shows *C. ovigerus* ($n = 5$) and other *Careproctus* ($n = 7$) using the disc regularly. Strong currents were absent from the areas where the disc was used, and snailfishes may use the disc to enable them to rest in any position on the substratum. Video records were also obtained of four snailfishes attached to tanner crabs (*Chionoecetes tanneri*) by their disc. Three appeared to be *C. melanurus*, and were all observed on dive V2548 in July 2004 at a depth of 1000 m. The fourth was an unidentified liparid attached to *Paralomis* sp. filmed on Rodriguez Seamount off central California (Fig. 8). Its identity is discussed above with *Careproctus* sp. from Monterey Canyon.

The liparids seen frequently had the lower pectoral fin rays (and sometimes the upper ones) erect. Specifically, one *C. gilberti*, seven *C. longifilis*, three *C. ovigerus*, six *C. melanurus* and two *O. cascadiae* were observed in this posture. Most of the *C. melanurus* were observed during video transects that provided little opportunity to determine fin positions. It would not be surprising to find many individuals drifting with their fins in this position because it is associated with feeding. Sakurai & Kido (1992) demonstrated that in *Careproctus rastrinus* Gilbert & Burke 1912, this behaviour was directly related to the presence of taste cells in high density on these rays, which fishes use to search for food items. The upper pectoral fin ray of *C. longifilis* is extraordinarily long (almost half the length of the body), a unique character among snailfishes. Its function has been unknown until now. The videos showed, however, that *C. longifilis* almost always held its pectoral fins out horizontally at right angles to the body while swimming [Fig. 4(d)]. It may use its extended rays as sensory 'antennae' to aid in prey and predator detection. The data show that other liparids commonly use the elongate lower pectoral fin rays as a sensory device, but none of them use the upper rays also.

The analysis of an archived video collection illustrates both the advantages and disadvantages of incidentally collected information in documenting fish occurrence, distribution and behaviours. The findings provide some of the first *in situ* observations of members of the Liparidae.

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