

## Photographic Investigations on Three Seamounts in the Gulf of Alaska<sup>1</sup>

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**ABSTRACT:** Geological and biological features of three of nine Gulf of Alaska seamounts surveyed by the National Marine Fisheries Service during the summer of 1979 are compared and discussed. A modified free vehicle photographic system, which produced the first photographs of the fauna and substrate on the summits of Patton, Giacomini, and Quinn seamounts, is described. Interpretations of echo sounding data, a limited number of rock samples, photographs from the seamount summits, and exploratory fishing catches are also presented. Geological features described as characterizing the summits of the three surveyed seamounts seem consistent with similar features described from other Pacific basin seamounts (Hess 1946, Menard and Dietz 1951, Murray 1941, Palmer 1966). The taxonomic composition of the observed epibenthic invertebrate fauna, and demersal and benthopelagic fishes, is discussed. Patton seamount is described as having the greatest taxonomic diversity. Photographs from the summits of Patton, Giacomini, and Quinn seamounts are presented.

RISING STEEPLY FROM THE deep-sea floor, the isolated, submerged mountains known as *seamounts* are prominent and fascinating features of the ocean basins. Hess (1946) reported some 160 comparatively smooth, flat-topped pinnacles in the Pacific basin which he termed *guyots*. Menard (1959) listed over 1400 seamounts, but also suggested that probably only about 10 percent of the true number in the Pacific were actually known. Larina (1975) reported Menard's estimates were too large and counted approximately 6500 seamounts greater than 0.5 km in height in the Pacific. In the Gulf of Alaska, many seamounts rising from 1000 m to over 3500 m above the deep-sea floor have been mapped (Herlinveaux 1971, Menard and Dietz 1951, Murray 1941); many are known to occur in groups or

clusters known as *provinces* (Menard and Dietz 1951, Palmer 1966).

The majority of seamounts in the Pacific basin are volcanic in origin and, until recently, the major interest in seamounts has been geological (Budinger 1967, Bullard and Mason 1963, Grossling 1970, Heezen and Menard 1963, Menard and Dietz 1951, Menard and Ladd 1963, Nayudu 1962). Biological studies of seamounts have been relatively rare (Herlinveaux 1971, Pratt 1963, 1967, Scigel 1970). In 1967, the discovery by Soviet trawlers of substantial, commercially exploitable populations of pelagic armorhead (*Pentaceros richardsoni*) and alfonsoin (*Beryx splendens*) over central North Pacific seamounts northwest of Midway Island (Sakiura 1972)—coupled with the subsequent exploitation of these species by Japanese and Soviet fishing vessels (Chikuni 1970, 1971, Takahashi and Sasaki 1977)—demonstrated the necessity for biological surveys to determine the nature and quantity of marine life associated with seamounts and to ascertain whether similar conditions might exist over some of the shoaler seamounts in the Gulf of Alaska.

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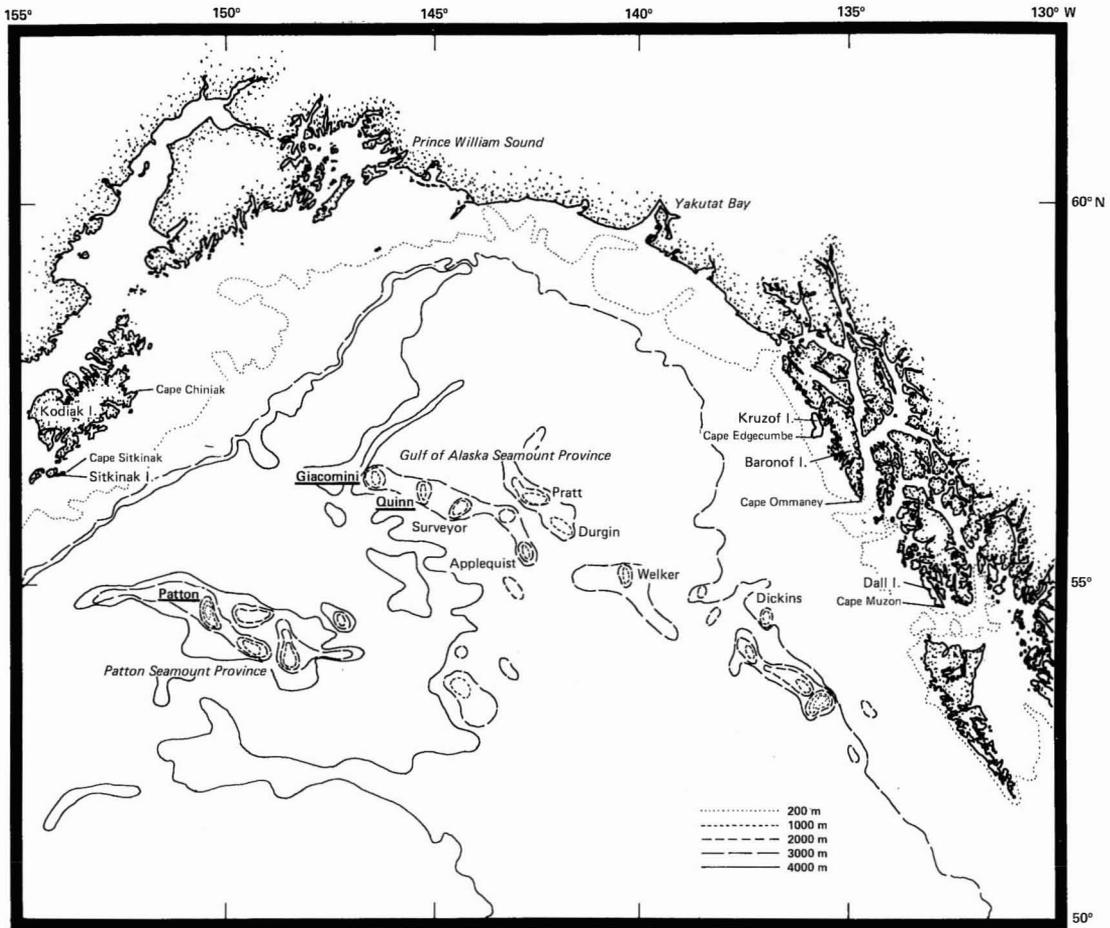


FIGURE 1. Location of seamounts investigated during the 1979 Gulf of Alaska seamount survey. Bold type and underlining indicate seamounts on which the modified free vehicle photographic system was deployed. The bathymetry shown is based upon U.S. National Ocean Survey chart INT 500 (3d ed., May 1979).

The first attempt by U.S. National Marine Fisheries Service (NMFS) investigators to assess the occurrence, distribution, and relative abundance of fish and shellfish fauna associated with Gulf of Alaska seamounts was made on the 33-m (108-ft) chartered fishing vessel *Sunset Bay*. Between 24 May and 6 July 1979, nine of the shoaler seamounts in the Gulf of Alaska (Figure 1) were surveyed with a large assortment of exploratory fishing gear (Hughes 1981).

The nine seamounts rise from the ocean basin at depths of 2400–4300 m to within 168–746 m of the ocean surface. The area of

their summits ranges from approximately 3.4 km<sup>2</sup> to 240.0 km<sup>2</sup>, and averages 82.3 km<sup>2</sup>. The summits of three seamounts were also investigated with a baited deep-sea photographic system that produced the first photographs of their faunal assemblages and geologic and microrelief features (Table 1).

Prior biological photographic investigations in the deep sea have documented species interactions and behaviors, population densities and composition, and spatial and vertical distributions for a variety of deep-sea organisms (Baker 1957, Barham, Ayer, and Boyce 1967, Grassle et al. 1975,

TABLE 1

STATIONS WHERE THE MODIFIED FREE VEHICLE PHOTOGRAPHIC SYSTEM WAS DEPLOYED DURING THE 1979 GULF OF ALASKA SEAMOUNT SURVEY

STATION CODE	SEAMOUNT	POSITION:		SUMMIT PLATFORM CONFIGURATION			
		LATITUDE AND LONGITUDE	DATE	WIDTH (km)	LENGTH (km)	AREA (km <sup>2</sup> )	DEPTH RANGE (m)
C <sub>2</sub>	Patton	54°32.4' N, 150°30.3' W	30 June	7.4	11.1	82.3	182-930
C <sub>3</sub>	Giacomini	56°26.6' N, 146°24.5' W	2 July	7.4	9.3	68.9	676-732
C <sub>4</sub>	Giacomini	56°28.1' N, 156°24.2' W	3 July				
C <sub>5</sub>	Quinn	56°18.1' N, 145°12.4' W	4 July	5.6	7.4	41.5	682-823
C <sub>6</sub>	Quinn	56°17.5' N, 145°16.2' W	5 July				

Isaacs and Schwartzlose 1975, Lemche et al. 1976, Rowé 1971, Scagel 1970, Thiel and Rumohr 1979). In general, these studies have explored continental shelves, abyssal plains, and ocean trenches throughout the world oceans; relatively few have been conducted on seamount summits (Isaacs and Schwartzlose 1975, Pratt 1967).

The present paper describes analyses of 16 color and 72 monochromatic photographs obtained between 29 June and 6 July 1979 on the summits of Patton, Giacomini, and Quinn seamounts. The primary objectives of these seamount photographic investigations were to ascertain the habitats, species composition, and behaviors of the benthic fish and invertebrate fauna; to document geologic and microrelief features of the seamount summits; and to demonstrate the feasibility of using a baited deep-sea benthic camera system as a comparative sampling method.

Benthic photographs can provide useful data on the species composition, spatial distributions, habitat characteristics, and population densities of organisms that are abundant and easily identifiable. However, photographs may be difficult to interpret in the absence of corroborating samples (Rice et al. 1979). In the present study, specimens of species identified were obtained from concurrent NMFS exploratory fishing opera-

tions. In addition, several incidental samples of basaltic pebbles and cobbles with attached benthic fauna were obtained during recovery of fishing gear used on the seamount summits.

#### MATERIALS AND METHODS

##### *Exploratory Fishing Gear*

Hughes (1981) described the survey and fishing gear used during the NMFS Gulf of Alaska seamount investigations. Extensive acoustic depth sounding transects were made over the summits of each seamount to determine topographic profiles and positions for trawl hauls and fixed fishing gear. Demersal fish and shellfish were collected between 29 June and 6 July 1979, with baited sablefish (*Anoplopoma fimbria*) traps and king crab pots fished in strings (Hipkins 1974) on the seamount summits.

##### *Photographic System*

A modified free vehicle photographic system (MFVPS) was used. It included a camera, electronic flash, external timer and trigger switch, ballasted bait cans, backup magnesium release device, and flotation package. The major component of the system

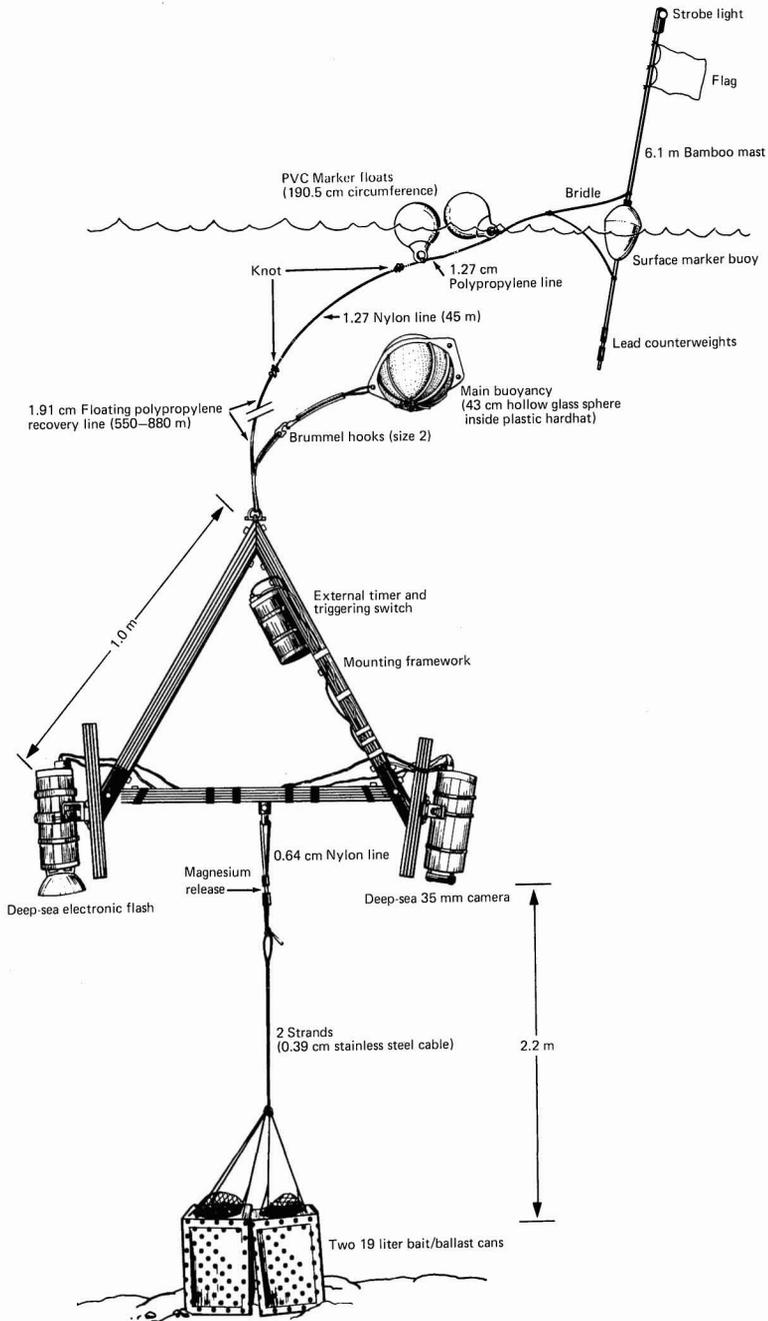


FIGURE 2. The modified free vehicle photographic system used to photograph features on the summits of three seamounts in the Gulf of Alaska. The drawing illustrates the orientations of the various components.

TABLE 2

## CHARACTERISTICS OF PHOTOGRAPHIC COMPONENTS USED IN THE MODIFIED FREE VEHICLE SYSTEM

PHOTOGRAPHIC COMPONENT	HOUSING DIAMETER (mm)	HOUSING LENGTH (mm)	WEIGHT IN AIR (kg)	WEIGHT IN WATER (kg)	BATTERY TYPE AND POWER
205 camera	127	432	6.8	2.7	Eveready #413, 30 V
206 flash	127	368	6.5	2.4	Eveready #497, 510 V
Electronic timer and trigger switch	114	229	2.7	1.1	Eveready #243, 4.5 V

was a Scripps Institution of Oceanography (SIO) free vehicle photographic system modified by the addition of a 1.91-cm diameter polypropylene recovery line attached to a surface marker buoy, as diagramed in Figure 2 (Hessler, Isaacs, and Mills 1972, Isaacs and Schick 1960, Phleger et al. 1970, Schick, Isaacs, and Sessions 1968, Shutts 1975, Shutts and Cooke 1975). The ballasted bait cans rested on the sea floor, and the camera and light source were suspended above the cans at a height of 2.2 m.

The photographic system consisted of an E. G. and G. (Edgerton, Germeshausen and Grier, Inc.) model 205 35-mm deep-see still camera with fixed focus  $f/4.5$  underwater corrected Hopkins lens (Hopkins and Edgerton 1961), E. G. and G. model 206 50-W-sec deep-sea electronic flash, and Geodyne model V4-14 external timer and trigger switch.<sup>3</sup> These devices were enclosed in individual pressure-resistant cylindrical aluminum housings and were mounted, with adjustable clamps, onto a triangular metal frame constructed with Unistrut® framing materials and fittings. The electronic flash was powered by an internal 510-V battery (Table 2), and the camera had a capacity of 22–24 exposures on a standard 36-exposure 35-mm film cassette. The lens was focused at 2.7 m in water, and the depth of field at  $f/5.6$  was 2.1–4.0 m. The camera could be programmed to make exposures at intervals of

5–60 min, and had a maximum operational depth capability of 3000 m. The complete photographic system weighed approximately 69.6 kg in air.

The flotation package consisted of a marker buoy constructed from a 6.1-m bamboo mast supported by an inflatable PVC (polyvinyl chloride) float and lead counterweights. A stroboscopic light and fluorescent orange flag were fastened to the mast. Two additional PVC floats (190.5-cm circumference) were attached to the mast and camera system by a polypropylene bridle. The bridle was attached to 45 m of sinking (1.27-cm diameter) nylon line to prevent fouling the propeller of the ship during recovery. The nylon line was attached to 550–880 m (length varied with depth to seamount summit) of 1.91-cm diameter floating polypropylene recovery line. The main buoyancy of the MFVPS consisted of one 43-cm diameter spherical glass float in a rigid plastic casing (hardhat). A 60-cm length of 1.27-cm diameter polypropylene line and two Brummel hooks (size 2) connected the glass float to the photographic frame and recovery line.

Two perforated 19-liter (5-gal) metal bait cans (with tops 235 mm square) were ballasted with 30 kg of anchor chain links. The cans were baited with 4.5 kg of frozen Pacific herring (*Clupea harengus pallasii*), sablefish, or a mixture of both (Table 3), covered with nylon webbing to prevent bait loss, and attached to the MFVPS with a corrosible steel-coated magnesium release device (Schick et al. 1968, Shutts 1975) set to

<sup>3</sup> Reference to trade names does not imply endorsement by the National Marine Fisheries Service.

TABLE 3  
DATA FOR EACH DEPLOYMENT OF THE MODIFIED FREE VEHICLE PHOTOGRAPHIC SYSTEM

STATION CODE	INTERVAL BETWEEN EXPOSURES (min)	TOTAL FRAMES EXPOSED	FILM TYPE*	BAIT USED	SET DEPTH† (m)	TIME‡		TOTAL SET TIME (hr)
						SET (hr)	RECOVERED (hr)	
C <sub>2</sub>	5	19	PX	Herring	433	1155	1330	1.6
C <sub>3</sub>	15	18	PX	Herring and sablefish	689	0845	1330	4.5
C <sub>4</sub>	15	23	PX	Sablefish	689	1300	1900	5.5
C <sub>5</sub>	15	16	KC	Sablefish	744	1730	2205	4.6
C <sub>6</sub>	15	22	PX	Sablefish	796	0800	1345	5.8

\*PX = Kodak Plus-X monochromatic print film (ASA 125); KC = Kodak Kodacolor-400 color print film (ASA 400).

†Set depth = depth to seamount summit at deployment position.

‡Time set = time system began descent to sea floor; time recovered = time system started ascent.

release the ballasted cans in 18–30 hr (unless the MFVPS was recovered earlier).

### Field Procedures

A hydraulic crane and pelican hook were used to deploy the MFVPS. The photographic frame and ballasted bait cans were attached to a pelican hook, lifted from the stern deck of the *Sunset Bay*, swung over the starboard railing, and lowered into the sea until the camera and flash were submerged. The pelican hook was released; then the recovery line was set as the MFVPS descended and the ship was made underway with a speed of approximately 0.5 knot (1 knot = 0.51 m/sec). The marker buoy and floats were deployed last. During recovery, the buoy and floats were brought aboard first, followed by the recovery line, glass float, frame, release device, and bait cans.

The presence of fog and rough seas and the lack of a radio beacon on the marker buoy mast required the vessel to tend the surface float to which the MFVPS was attached to prevent its loss. The usual procedure was to deploy the MFVPS, tend the marker float, recover the MFVPS, and then proceed with standard exploratory fishing operations.

Five successful deployments and recoveries of the MFVPS were made (Tables 1

and 3). During the first deployment on Patton seamount (station C<sub>2</sub>), an exposure interval of 5 min was chosen to test the MFVPS for proper functioning. Time schedule constraints necessitated moving on to Giacomini seamount before a second, longer deployment could be made on Patton. Two successful deployments each were made on Giacomini and Quinn seamounts using 15-min intervals between exposures. Total deployment times ranged from 1.6 hr on Patton to 5.8 hr on Quinn. Longer deployments were not practical because of poor weather conditions and the necessity to tend the marker buoy during a set.

The MFVPS was designed to attract demersal and benthopelagic fish and invertebrates to baited cans suspended within view of its camera, and to sequentially photograph those organisms. The plane of focus for the MFVPS was at the tops of the bait cans. The area of the sea floor depicted in a single photographic frame could be estimated only when the bait cans (235 mm square by 350 mm tall) were included in the photograph. Each photographic negative depicts an area approximately  $1.6 \times 2.4$  m ( $3.8$  m<sup>2</sup>). The precise area photographed varied because ocean currents caused the MFVPS to tilt. The resultant photographs, made at an oblique rather than a vertical angle, made it impossible to obtain reliable density esti-



FIGURE 3. Patton seamount, station C<sub>2</sub>, 433 m, 1230 hr. This photograph shows a scorpaenid fish (S), *Sebastolobus* sp., resting on the substrate. The fish appears attracted to the sediment cloud created by the dragging bait cans. Ring-shaped sponges (Pr), a bryozoan colony (B), scallops (Sc), and numerous serpulid tubeworms (T) are shown attached to the cobbles and pebbles which characterize the substrate on this seamount.

mates for the megafaunal (Grassle et al. 1975) organisms photographed.

Corroborating bottom samples, useful in interpreting biological features depicted in the photographs, could not be obtained. Consequently, faunal identifications are limited to major taxa. Generic and specific names are employed only when samples, obtained from the accompanying exploratory fishing operations, enabled verification.

The MFVPS performed extremely well and demonstrated the feasibility of using a simple and compact benthic photographic system during NMFS resource assessment surveys. One problem encountered was drifting of the MFVPS and dragging of the bait cans caused by the effects of current and wind on the surface marker buoy and recovery line. Increasing ballast and relocating

the glass float closer to the frame corrected the problem.

Separate strings consisting of 9–11 baited sablefish traps and king crab pots fished from common groundlines were set at different locations on the summits of the seamounts. The strings were deployed in pairs and soaked for 24 hr. Upon recovery, the catch was sorted; crabs and fish were identified, counted, weighed, and measured, and selected specimens of sablefish were tagged and released. Trap frames and webbing were inspected, and incidental samples of rocks, bottom debris, and benthic organisms were removed and examined. Between 29 June and 6 July 1979, two strings each were successfully fished on Patton and Quinn and four strings were fished on Giacomini (Hughes 1981).

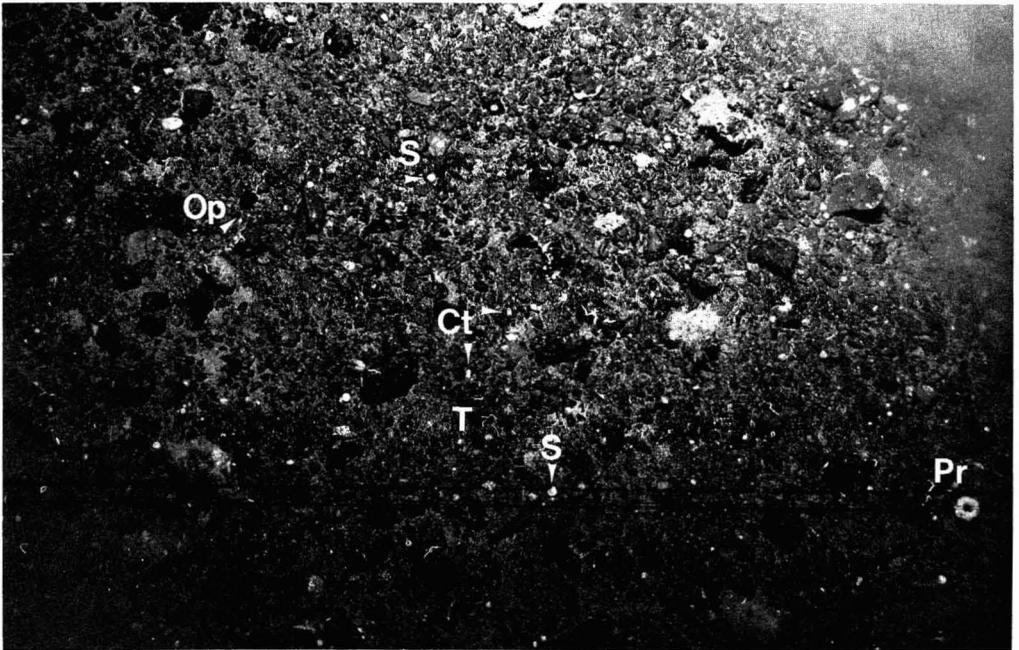


FIGURE 4. Patton seamount, station C<sub>2</sub>, 433 m, 1245 hr. A ring-shaped sponge (Pr), several chitons (Ct), serpulid tubeworms (T), numerous scallops (S), and several ophiuroids (Op) are visible. Rounded and subrounded basaltic pebbles and cobbles suggest Patton is a submerged wave-planed abrasional platform.

## RESULTS

### *Topographic and Geologic Features*

The summit of Patton, though relatively flat in general profile, is characterized by numerous rocky pinnacles and canyons. It measures approximately  $7.4 \times 11.1$  km ( $82.3 \text{ km}^2$ ), and the depth to the summit ranges from 182 m to over 900 m. Areas shoaler than 360 m are primarily rocky pinnacles. Relatively flat areas having softer substrates are rare and occur mainly in the southwest quadrant. Patton is the shoalest seamount summit station photographed (Table 1).

The numerous rounded and subrounded basaltic cobbles and pebbles, as well as the sorting of these materials (depicted in Figures 3–6), indicate Patton is a submerged wave-planed abrasional platform (Larina 1975, Menard 1964, Palmer 1966). The streaming of the nylon line on the bait can

shown in Figure 6, the bend in the rachis of the pennatulid (sea pen) in Figure 5, and the absence of fine-grained sedimentary materials (Figures 3–7) indicate the area photographed was subject to a fairly strong current. The scarcity of deposited sediment further suggests the presence of persistent current scour or the lack of a source of sedimentary materials. Figure 7 depicts what appears to be basaltic pillow structures typical of the subaqueous extrusion of lava. The pillow formations are evidence which suggest a volcanic origin for Patton seamount (Heezen and Menard 1963, Menard 1964, Palmer 1966).

Giacomini is a rather flat-topped seamount of symmetrical profile. Its summit measures  $7.4 \times 9.3$  km ( $68.9 \text{ km}^2$ ), and depth to the summit varies between 676 and 732 m. The substrate on the summit is predominantly soft sediment; however, several scattered rocky pinnacles were detected acoustically.

Photographs from Giacomini show a

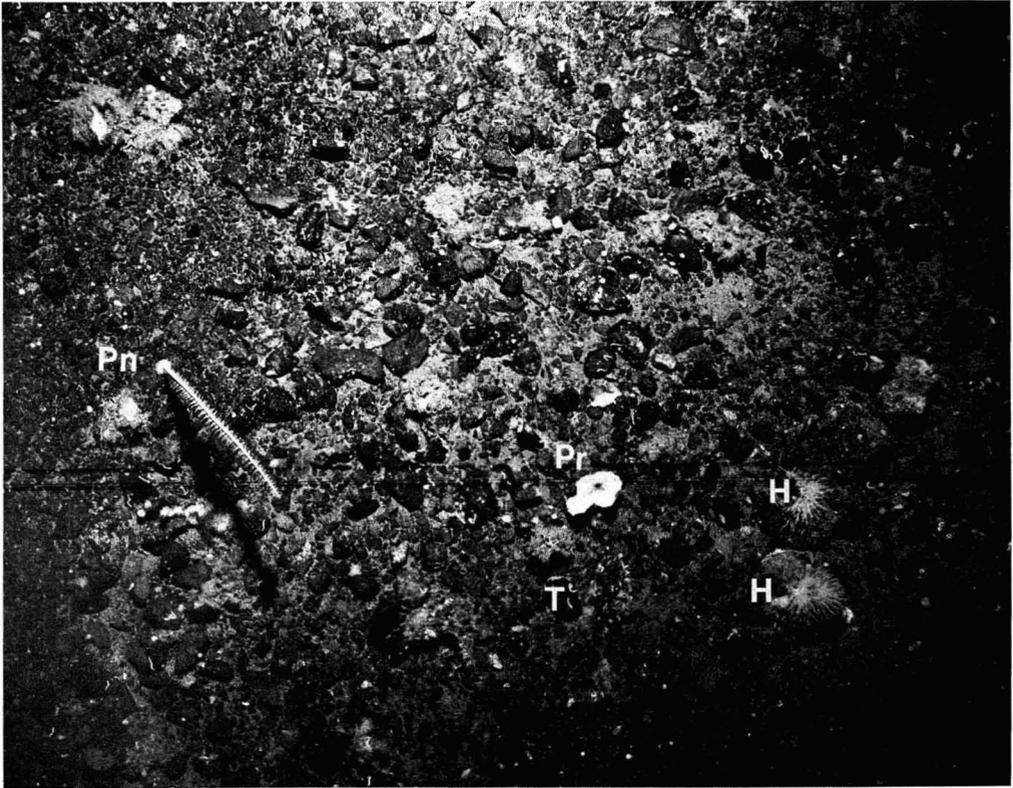


FIGURE 5. Patton seamount, station C<sub>2</sub>, 433 m, 1255 hr. The bend in the rachis of the sea pen (Pn) and the absence of accumulated sediments on the exposed cobbles and pebbles suggests a persistent current scour or the lack of a source of sedimentary materials. Serpulids (T), hydroid colonies (H), and a large ring-shaped sponge (Pr) are among the most easily recognizable invertebrate fauna.

ripple-marked sediment with a few scattered, partially exposed rocks (Figures 8–10). Very little evidence of the presence of burrowing or attached epibenthic organisms is detected (Figure 9). The scarcity of megafaunal burrowing organisms suggests a thin veneer (possibly only 4–8 cm) of unconsolidated sediment. The sediment appears to overlie a relatively smooth and firm substrate. Ripple marks in the sediment (Figures 8, 9) indicate the presence of a moderately strong, largely unidirectional current. The lack of attached benthic fauna suggests that the substrate is firm, but not indurated, and that the thin veneer of fine-grained sediment is mobile and discourages settlement. The light-colored patches that appear in Figures 8–10 suggest that the underlying substrate might

be carbonate ooze, limestone, or coralline in nature.

The Quinn seamount profile has the typical flattened top characteristic of a guyot (Hess 1946). The summit, at depths of 682–823 m, measures 5.6 × 7.4 km (41.5 km<sup>2</sup>). Extremely steep flanks, an absence of rocky pinnacles, and the presence of large areas of soft sediment characterize this seamount. Photographs from the summit of Quinn at a depth of 796 m (Figures 11, 12) show well-rounded pebbles and cobbles scattered over a thin mantle of fine-grained sediment. The exposed pebbles suggest a moderate current, sufficient in velocity to sweep the pebbles and cobbles clean, but not of sufficient velocity to prevent sediment accumulation completely. Figure 13 (station

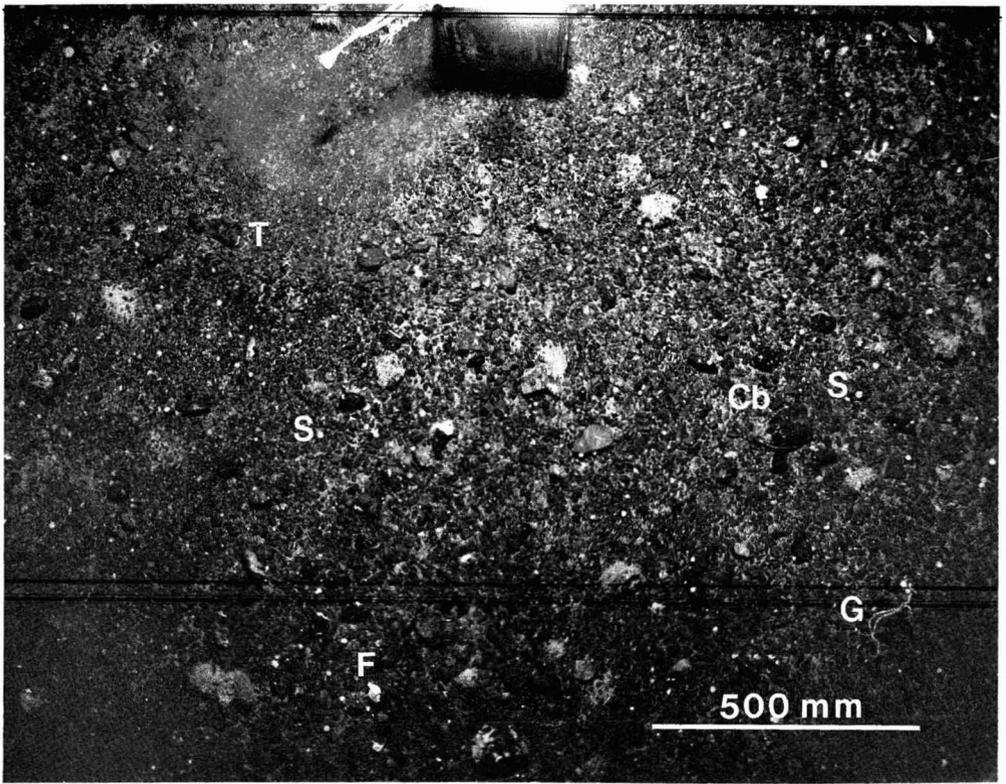


FIGURE 6. Patton seamount, station C<sub>2</sub>, 433 m, 1305 hr. The streaming of the nylon line on the bait can (235 mm square), the exposed cobbles (Cb) and pebbles, and lack of accumulated sediments indicate the presence of a moderately strong current. Scallops (S), serpulid tubeworms (T), the snail *Fusitriton oregonensis* (F), and a gorgonian skeleton (G) are shown.

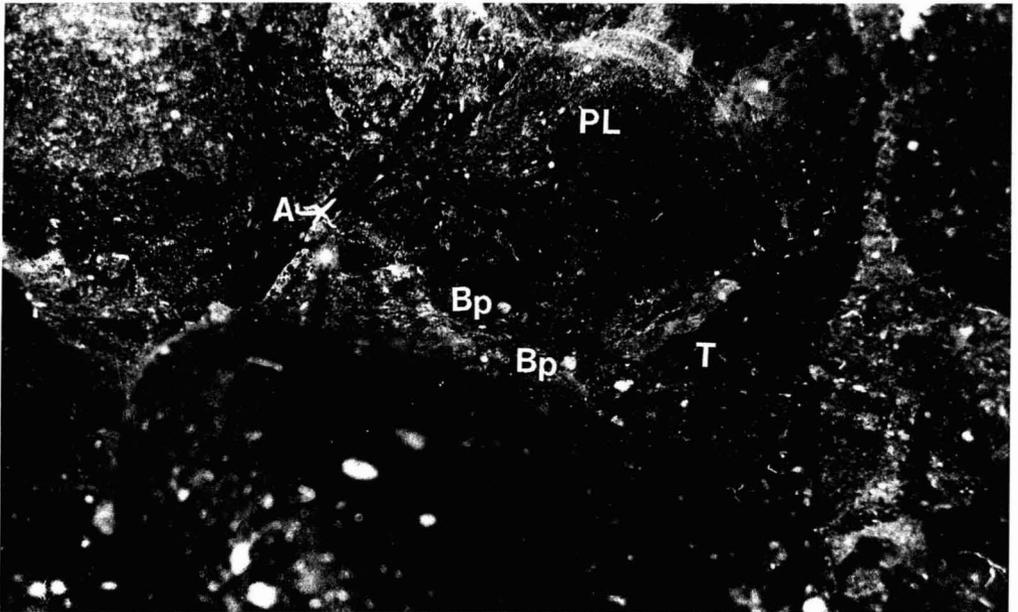


FIGURE 7. Patton seamount, station C<sub>2</sub>, 433 m, 1320 hr. This photograph shows an area of pillow lava structures (PL) typical of the subaqueous extrusion of lava and provides evidence of a volcanic origin for Patton seamount. The pillow structures appear to be free of sediment and attached invertebrate fauna. A few brachiopods (Bp), scattered serpulid worms (T), and an unidentified asteroid (A) are the only invertebrate epifauna in evidence.



FIGURE 8. Giacomini seamount, C<sub>4</sub>, 689 m, 1630 hr. This photograph shows the ripple-marked sediment (R) which characterizes the summit of Giacomini seamount. The light-colored patches (Lp) suggest the existence of carbonate ooze, limestone, or possibly a coralline substrate beneath a thin veneer of unconsolidated surface sediment. Several deep-sea king crab, *Lithodes couesi* (L), and several snow crab, *Chionoecetes tanneri* (C), are shown attracted to the baited cans. Attached epibenthic invertebrate fauna are absent, and there is little evidence of infauna.

C<sub>5</sub>), from a depth of 744 m, shows a fine-grained, partially indurated sediment with angular blocks and cobbles. A submerged wave-planed terrace with a thin veneer of sediment overlying a fractured rock substrate exhibits features similar to those depicted in Figures 11 and 12. The angularity of the blocks and cobbles depicted in Figure 13 suggests the existence of a nearby fault escarpment from which the blocks and cobbles have fallen onto the sediment on the crest of Quinn seamount.

### Biological Features

Patton seamount exhibits the greatest diversity in topography and microrelief, and is

also characterized by the highest relative faunal diversity of the three seamounts investigated. Table 4 summarizes the taxa observed on each seamount and, where discernible in the photographs, the total number of individual taxon members shown in all photographs from each camera deployment station.

Only one fish species, a scorpaenid in the genus *Sebastolobus* (probably *S. altivelis*), was photographed at station C<sub>2</sub> on Patton (Tables 1 and 4). The fish, shown in Figure 3 resting on the substrate supported by its pelvic fins, seems attracted to the sediment cloud created by the dragging bait cans. This species was photographed in 2 of 19 total frames exposed at station C<sub>2</sub>. Other frames from Patton show a variety of attached epi-

TABLE 4

SUMMARY OF TAXA AND SPECIES OBSERVED IN PHOTOGRAPHS FROM THE SUMMITS OF SEAMOUNTS INVESTIGATED DURING THE 1979 GULF OF ALASKA SEAMOUNT SURVEY

FAUNA	PATTON C <sub>2</sub>	GIACOMINI		QUINN	
		C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>
Porifera (sponges)	+			+	+
Cnidaria					
Pennatulacea (sea pens)	+(1)				
Gorgonacea (horny corals)	+(2)				
Ceriantharia (sea anemones)			+(5)		
Hydroida (hydroids)	+				
Mollusca					
Polyplacophora (chitons)	+				
Prosobranchia (snails)	+(2) <sup>a</sup>		+(1) <sup>b</sup>		
Bivalvia (scallops)	+				
Polychaeta (Serpulidae)	+				+
Bryozoa (Ectoprocta)	+				
Brachiopoda (lamp shells)	+				
Echinodermata					
Asteroidea (sea stars)	+(6) <sup>c</sup>			+(1)	
Holothuroidea (Psolidae)		+(2)		+(3)	+(5)
Ophiuroidea (brittle stars)	+			+	+
Arthropoda					
Lithodidae ( <i>Lithodes couesi</i> )	+(1)	+	+	+	+
Majidae ( <i>Chionoecetes tanneri</i> )		+	+	+	+
Total invertebrate taxa	13	3	4	6	6
Pisces					
<i>Sebastolobus</i> sp.	+(2)	+(1)		+(2)	
<i>Coryphaenoides pectoralis</i>		+(1)		+	+
<i>Coryphaenoides cinereus</i>					+
<i>Coryphaenoides acrolepis</i>		+			+
Total pisces species	1	3	0	2	3

NOTE: Photographs are prints enlarged to 10× from 35-mm negatives. Taxa are identified by the author; identifications at the species level are based on specimens captured during exploratory fishing operations. Explanation of symbols: + = taxa visible in photographs from station; (#) = total number of individuals photographed at specified station; <sup>a</sup> = snails identified as *Fusitriton oregonensis*; <sup>b</sup> = unidentified snail; <sup>c</sup> = four species.

benthic invertebrate fauna. A total of 13 invertebrate taxa have been identified in the 19 Patton photographs. Three cnidarian taxa are shown; one sea pen (Figure 5), several calcareous gorgonian skeletons (Figure 6), and numerous hydroid colonies (Figure 5) are identifiable. Serpulid polychaete tubes were common on the larger cobbles. Ring-shaped sponges, foliaceous bryozoan colonies, brachiopods, chitons, two snails (*Fusitriton oregonensis*), numerous small scallops, asteroids (six individuals and possibly four species), ophiuroids, and a single lithodid crab (*Lithodes couesi*) were identified in the Patton photographs. Many

of the identified invertebrate taxa are shown in Figures 3–7.

Giacomini seamount is characterized by an extremely soft sedimentary substrate. Photographs from station C<sub>3</sub> (Tables 1 and 3) were slightly out of focus due to camera movement (dragging) during exposure and would not adequately reproduce in halftone. The photographs revealed a few scattered, exposed rocks and substantially fewer attached epibenthic invertebrate taxa than were visible on Patton. Only three invertebrate taxa were detected in 18 frames exposed at station C<sub>3</sub> (Tables 1 and 4). Two crab species, the deep-sea king crab *Lithodes*



FIGURE 9. Giacomini seamount, station  $C_4$ , 689 m, 1700 hr. The rippled sediment, indicative of a moderately strong unidirectional current or irregularities in a firm substrate underlying the sediment, is shown marked by the burrow (Br) of an unknown infaunal organism. Deep-sea king crab and snow crab (C) are shown swarming over the baited cans. Such opportunistic feeding behavior is characteristic of these large, mobile scavengers. Scattered light-colored patches (Lp) are also visible.

*couesi* (family Lithodidae) and the snow crab *Chionoecetes tanneri* (family Majidae), and two holothuroids (family Psolidae), were the only invertebrate taxa photographed (Table 4). Two fish species were photographed at station  $C_3$ . One frame showed a solitary *Sebastes* sp. resting on the substrate, and another frame revealed a single (family Macrouridae) grenadier (probably *Coryphaenoides acrolepis*) swimming several centimeters above the substrate, away from the camera.

Station  $C_4$  photographs from Giacomini showed a substrate comparable to that found at station  $C_3$ . Fewer exposed rocks were photographed on station  $C_4$  because additional ballast and repositioning of the glass float reduced dragging, and the

MFVPS remained in essentially one location until it was retrieved. Epibenthic invertebrate fauna were sparse at station  $C_4$ . A total of five individual sea anemones (probably cerianthids; Figure 10), one unidentified snail (not *Fusitriton oregonensis*), and many individual *Chionoecetes tanneri* and *Lithodes couesi* (Figures 8, 9) aggregated on and around the bait cans, as seen in 23 frames exposed at station  $C_4$ . The crabs did not appear to be disturbed by the repeated photographs made by the MFVPS; the same individuals appear in most of the photographs in the series.

Stations  $C_5$  and  $C_6$  on Quinn seamount were characterized by substrates composed of a thin veneer of sediment and larger areas of exposed, rounded pebbles and scattered

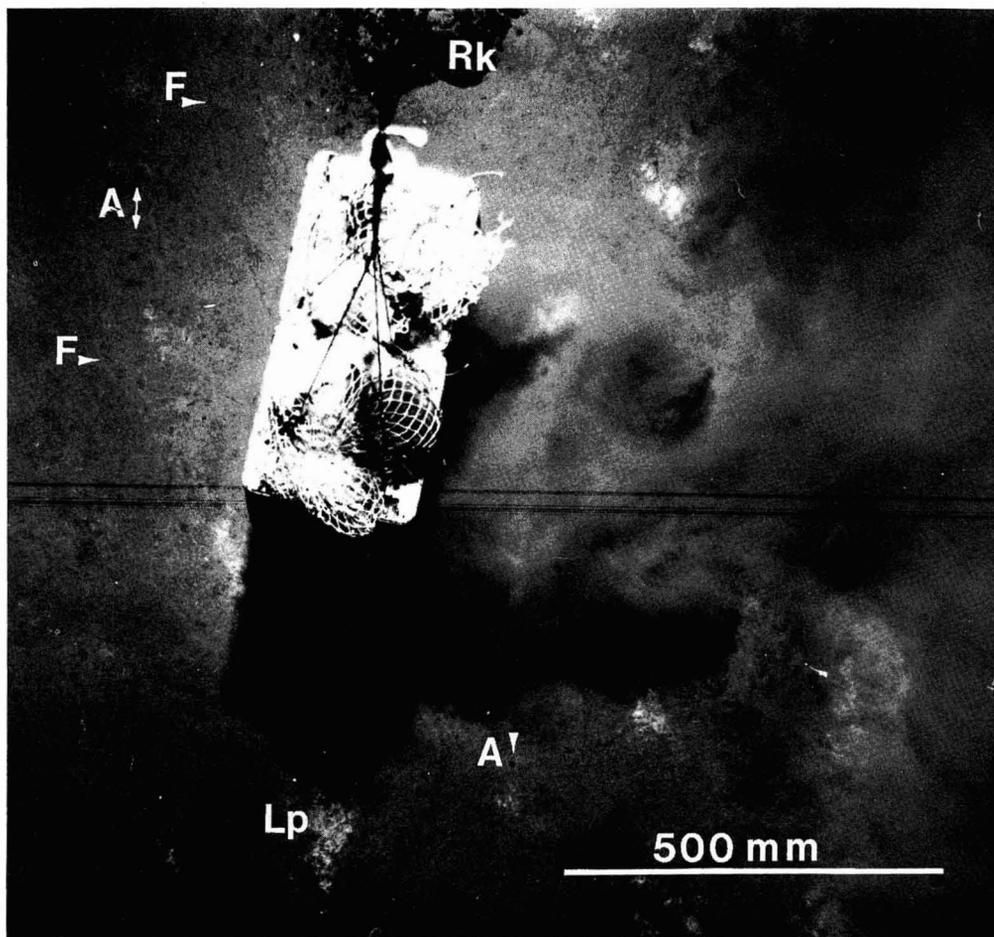


FIGURE 10. Giacomini seamount, station C<sub>4</sub>, 689 m, 1800 hr. This photograph shows one of the few exposed rocks (Rk) photographed on this seamount. A thin layer of sediment is visible on the rock, indicating the mobile nature of the sediment. Light-colored patches (Lp) and several infaunal cerianthid anemones (A) are also shown. The sediment cloud and the furrows (F) in the sediment indicate the bait cans and attached camera system were being dragged across the substrate.

cobbles and blocks. Some of the sediment at station C<sub>5</sub> on Quinn appears indurated (Figure 13).

Six epibenthic invertebrate taxa are noted in 16 color exposures made at station C<sub>5</sub>. Sponges, one asteroid, three holothuroids (psolids), numerous ophiuroids (white and orange colored; some exposed, some partially buried), and many deep-sea king crab and snow crab were photographed. In addition, two *Sebastolobus* sp. and several large grenadiers, believed to be *Coryphaenoides* (*Albatrossia*) *pectoralis* (the

largest of the grenadiers captured in fish traps), were photographed circling the bait cans at station C<sub>5</sub>. The grenadier believed to be *C. pectoralis*, several snow crab, several deep-sea king crab, three holothuroids, and small ophiuroids are shown in Figure 13.

Photographs taken at station C<sub>6</sub> on Quinn seamount revealed a faunal assemblage quite similar to that found at station C<sub>5</sub>. Sponges, holothuroids (psolids), ophiuroids, both crab species, and the large grenadier (*C. pectoralis*) were photographed at station C<sub>6</sub>. Two additional macrourid species, a smaller

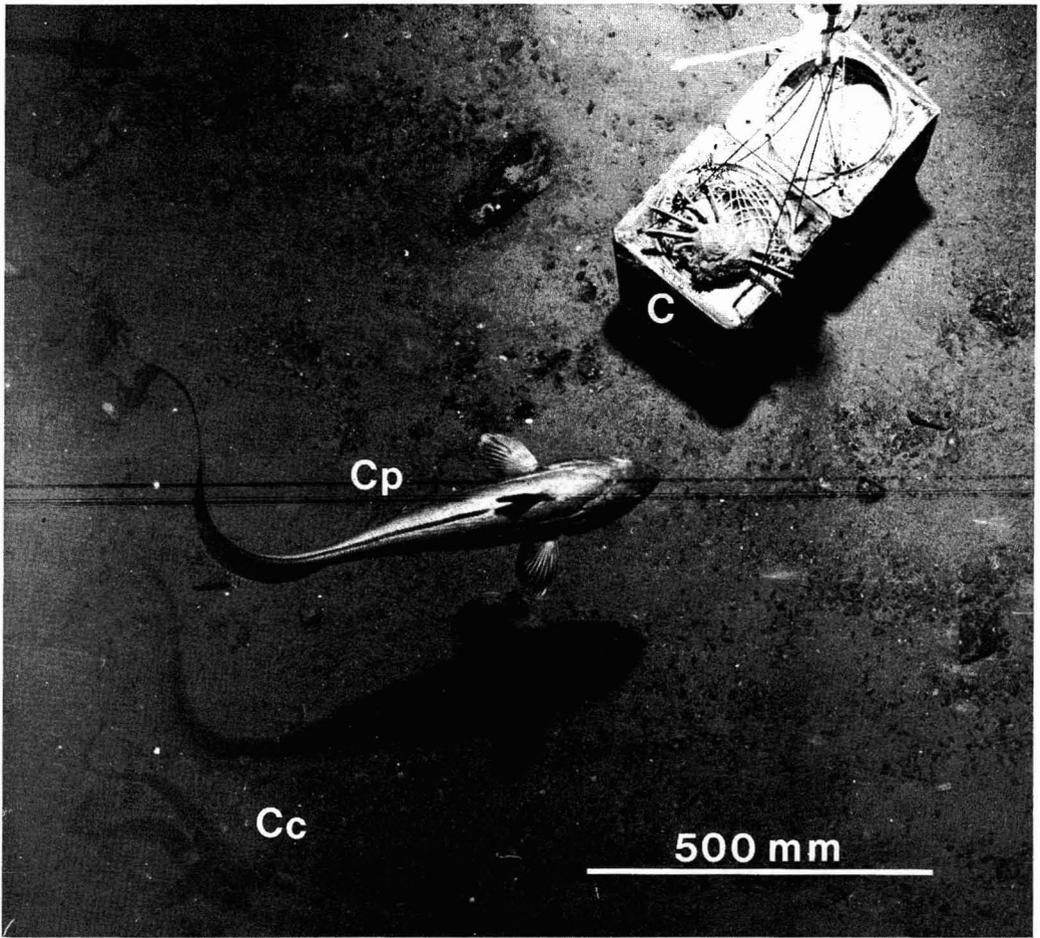


FIGURE 11. Quinn seamount, station  $C_6$ , 796 m, 0815 hr. Rounded, exposed pebbles, scattered cobbles, and patches of undisturbed sediment characterize station  $C_6$  on Quinn. Two of three macrourid (grenadier) species photographed on Quinn seamount appear here. The larger fish is believed to be *Coryphaenoides pectoralis* (Cp), and the smaller fish is believed to be *C. cinereus* (Cc). Identification of these species was based on comparisons of the photographs with specimens captured during exploratory fishing operations on this seamount. A solitary snow crab (C) is seen feeding on the bait in the net bag tied to the top of a bait can.

fish believed to be *C. cinereus* (smallest species captured during exploratory fishing on Quinn; see Figure 11) and an intermediate-sized macrourid believed to be *C. acrolepis* (dark in coloration and with a long outer ray on its pelvic fins; see Figure 12), were present at station  $C_6$ . No asteroids were photographed at station  $C_6$ , but a few serpulid polychaete tubes were seen on some of the larger cobbles. Many of the fish and invertebrate taxa described are shown in Figures 11–13.

#### DISCUSSION

Examination of photographs can reveal considerable information about the habits and habitats of seamount fishes and invertebrates (Marshall and Bourne 1964). Some organisms (Figures 3–8) rest on or are attached to the bottom, others (Figures 5, 9) burrow into the substrate, and many (Figures 11–13) swim just above the substrate.

Table 4 indicates that many of the taxa

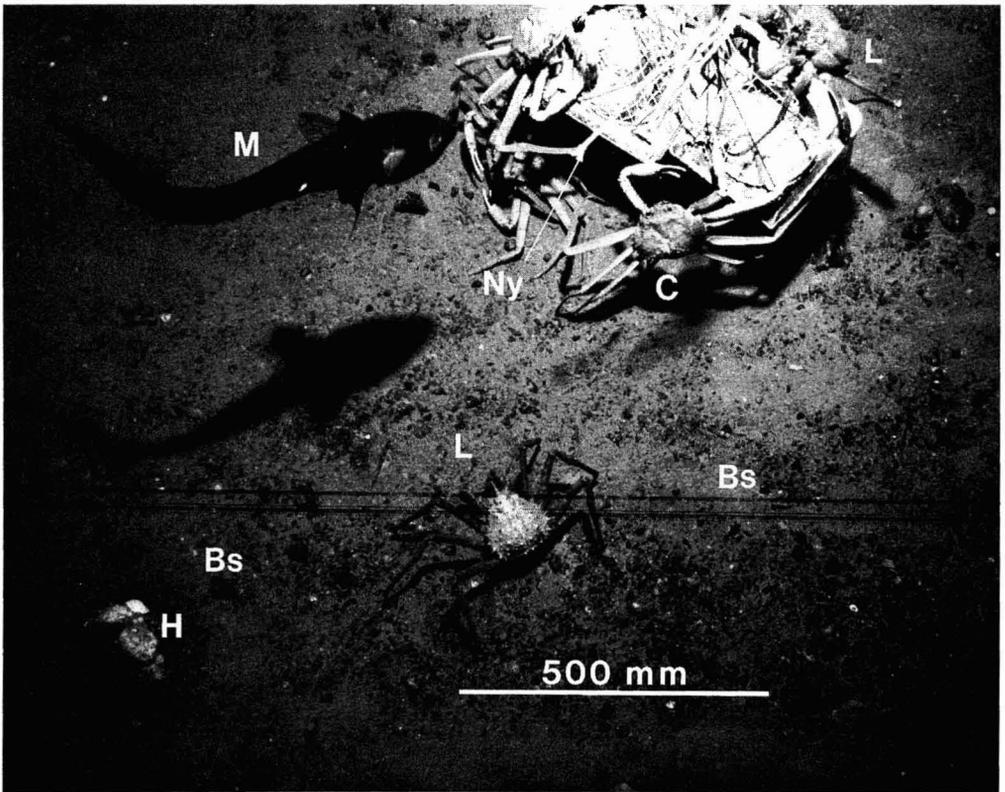


FIGURE 12. Quinn seamount, station C<sub>6</sub>, 796 m, 1015 hr. The third (*Coryphaenoides acrolepis*) dark-colored macrourid species (M) (see Figure 11) is photographed swimming above the substrate and observing the feeding activities of snow crab (C) and deep-sea king crab (L) on the bait cans. A streaming nylon line (Ny) indicates the direction of the apparent current; the macrourid is oriented facing into the current; and a deep-sea king crab (L) is shown approaching the bait cans from the down-current direction. The photograph also shows numerous brittle stars (Bs) and several holothuroids (H) (family Psolidae).

photographed on Patton but not on Giacomini or Quinn (or both) are forms that utilize hard, rocky substrates for attachment (i.e., gorgonians, hydroids, chitons, scallops, serpulid polychaetes, bryozoans, brachiopods) or are forms unable to tolerate soft, mobile fine-grained sediment (i.e., scallops, chitons, sponges). A cerianthid anemone (Figure 10) and a sediment-dwelling snail appear to prefer the softer substrate on Giacomini; neither was observed in photographs from Patton or Quinn. A total of 13 epibenthic invertebrate taxa from Patton seamount, 7 from Quinn, and 5 invertebrate taxa from Giacomini were photographed (Table 4).

The two common crab species (*Lithodes*

*couesi* and *Chionoecetes tanneri*) appear quite adaptable in their habitat tolerances. Deep-sea king crab and snow crab were photographed and captured on all three seamounts. The highest total numbers of both species caught during exploratory fishing operations (653 king crab and 465 snow crab) occurred on Giacomini seamount. It is not known whether the large numbers of crabs encountered on the seamounts are endemic populations isolated from populations on other seamounts and the western North American continental slope.

Rathbun (1925) described the depth range of *Chionoecetes tanneri* as 29–1062 fm (53–1942 m). Data collected by Pereyra (1966) on the continental slope off the

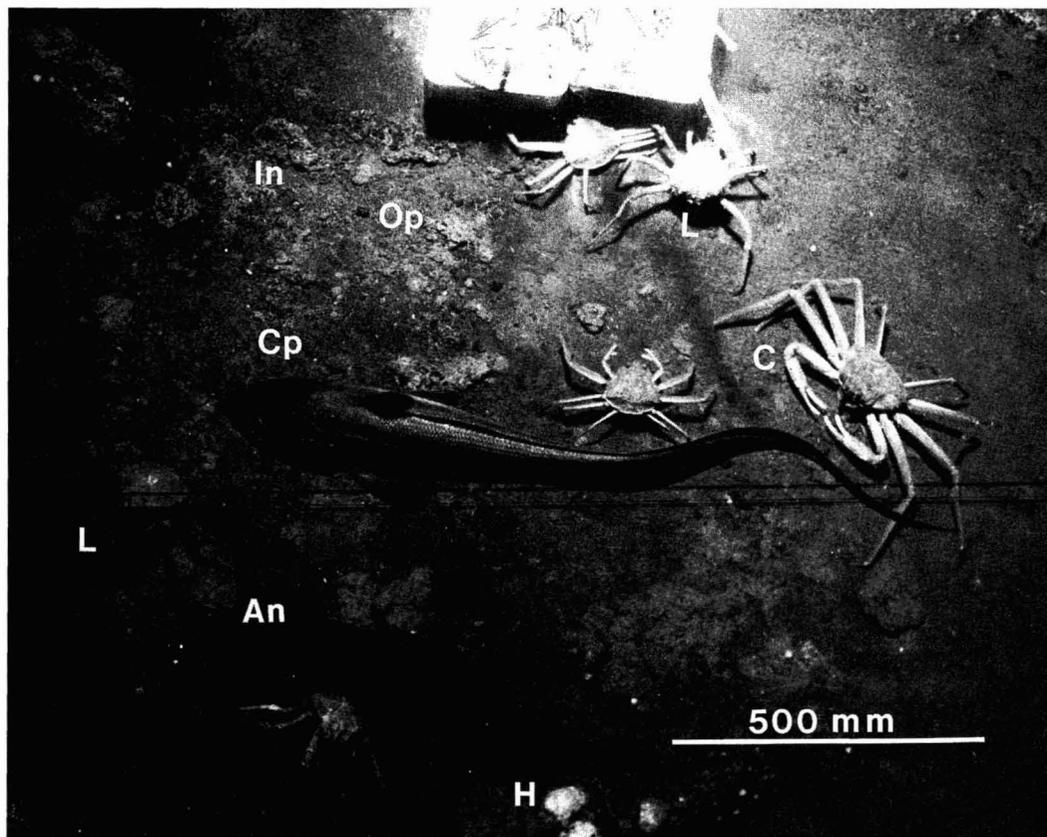


FIGURE 13. Quinn seamount, station C<sub>5</sub>, 744 m, 2015 hr. Angular blocks (An) and cobbles, and possibly indurated sediment (In) are shown. These features are characteristic of photographs obtained from this station, and suggest the existence of a nearby fault escarpment. Also shown are several snow crab (C), deep-sea king crab (L), holothuroids (H), ophiuroids (Op), and a grenadier fish believed to be *Coryphaenoides pectoralis* (Cp).

Oregon coast suggest that *C. tanneri* is primarily a deep-water species; specimens were only taken from 350–1050 fm (457–1920 m). Pereyra (1972) suggests that *C. tanneri* are excluded from shallower depths off the Oregon coast by the two congeners, *C. bairdi* and *C. opilio*, which were not taken in water deeper than 259 fm (474 m). *Chionoecetes bairdi* and *C. opilio* were not captured on any of the seamounts investigated in the Gulf of Alaska.

The depth range for *Lithodes couesi* is given as 542–1125 m by Sakai (1976). Somerton (1981) suggests that the shallow distribution of *L. couesi* on Gulf of Alaska seamounts (station C<sub>2</sub>, Patton was only 433

m) might be caused by the absence of predators or competitors that would normally exclude the species from shallow-water areas on the continental slope.

Details of the larval life histories and dispersal capabilities for these crabs are presently unknown. It is interesting to note that many of the deep-sea king crab and snow crab captured in exploratory fishing pots were carrying clutches of maturing eggs. The presence of these species on the seamounts may indicate the persistence of isolated populations or that immigrants from other seamounts, the ocean basin, continental slope, or shelf are reinforcing the original colonies (Pielou 1979).

Four fish species, a demersal scorpaenid (*Sebastolobus altivelis*) and three benthopelagic macrourids (*Coryphaenoides pectoralis*, *C. cinereus*, *C. acrolepis*), were photographed. The demersal scorpaenids were always photographed resting directly on the substrate and were oriented facing into the apparent current. This corroborates similar observations of this genus made by Barham et al. (1967) from the bathyscaphe *Trieste* in the San Diego trough. The benthopelagic macrourids were always photographed swimming near or a short distance above the substrate.

Hart (1973) reports a depth range for *Sebastolobus altivelis* of 200–365 to 1750 m. Iwamoto and Stein (1974) report depth ranges of 200–2170 m for *Coryphaenoides pectoralis*, 630–2832 m for *C. cinereus*, and 600–2500 m for *C. acrolepis*. They also report that *C. cinereus* and *C. acrolepis* are primarily inhabitants of continental slope waters. Novikov (1970) describes *C. pectoralis* as an inhabitant of the continental slope which occupies its widest depth range (400–1000 m) during the summer.

The presence of these macrourid species on seamounts in the Gulf of Alaska is consistent with their reported geographic distributions, which, in general, range from southern California to Alaska in the eastern Pacific and from Japan to the Okhotsk and Bering Seas in the western Pacific. Seamounts may act as temporary refuges during migrations, or may be inhabited permanently by endemic populations of these fishes.

An unexpected result was that sablefish were not photographed on any of the seamounts, even though they were the dominant fish species by weight and numbers caught in traps (Hughes 1981). This may have been due to differences in soak time or, possibly, bait. Sablefish traps were soaked 24 hr or longer and were baited exclusively with Pacific herring. Otherwise, different types of bait (sablefish or Pacific herring) did not seem to influence the attraction of fish or shellfish species to the photographic system.

Marshall and Bourne (1964) concluded that deep-sea photographic equipment had little effect on the behavior of benthopelagic fishes. Photographs obtained on Patton,

Giacomini, and Quinn seamounts corroborate this conclusion. In many photographs the same individual fish was repeatedly photographed.

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