FINAL
Survey Report

San Francisco Rock Removal
Benthic Survey Off Alcatraz Island, CA
for
San Francisco District,
U.S. Army Corps of Engineers

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Abstract

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A field survey of four submerged rock features and adjacent depressions (deeper water areas) conducted from September 11 through 15, 2001, in the vicinity of Alcatraz Island, San Francisco Bay, CA. In general, about 2.7 kilometers (km) of transects were surveyed using a remotely operated vehicle (ROV) to collect color video and color still camera data on the bottom and near-bottom biological communities and associated habitats. This represents about 0.5 to almost 1 km per feature. Approximately 10 hours of color video and about 200 photographs were collected, although the extremely poor visibility (e.g., less than 6 inches to a maximum of 2-3 feet) limited the usefulness of many data for detailed analysis. Nonetheless, these data are appropriate for characterizing these communities due to the generally low diversity and similarity of species among the sites.

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Survey Report

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1.0 SUMMARY

This document describes the results from a field survey of four submerged rock features and adjacent depressions (deeper water areas) conducted from September 11 through 15, 2001, in the vicinity of Alcatraz Island, San Francisco Bay, CA. Separate sections are presented on Site Description, Study Methods, Results and Discussion, Conclusions, and References. Appendices are included for Observer Logs, Navigational Coordinates, and Photographic Exhibit Examples. In general, about 2.7 kilometers (km) of transects were surveyed using a remotely operated vehicle (ROV) to collect color video and color still camera data on the bottom and near-bottom biological communities and associated habitats. This represents about 0.5 to almost 1 km per feature. Approximately 10 hours of color video and about 200 photographs were collected, although the extremely poor visibility (e.g., less than 6 inches to a maximum of 2-3 feet) limited the usefulness of many data for detailed analysis. Nonetheless, these data are appropriate for characterizing these communities due to the generally low diversity and similarity of species among the sites.

In general, the habitats at Harding, Shag, Arch, and Blossom Rocks are typified by boulders and cobble overlaying rocky reefs from the shallowest depths (35-40 feet) to about 70-85 feet, with scattered hard bottom to about 100 feet observed additionally at Blossom. Below these depths the substrate grades into coarse sand and gravel that commonly is dark gray to blackish in color, interspersed with shell debris. Finer grained sediments “dust” or cover most of the hard-bottom areas, consistent with the very high levels of turbidity that were present during the entire survey, and which are typical of San Francisco Bay waters. This high turbidity likely is caused by the combination of predominantly muddy-bottom habitats and strong tidal currents (e.g., commonly 1-4 knots) that serve to resuspend and transport this material in the Bay.

The biological communities on the four rock features are similar to those at similar depths in many hard-bottom marine habitats of the central California coast. However, within the San Francisco Bay region, rock features and associated species of this type are an uncommon resource. The most common species on each of the four features were seastars, “turf” organisms (comprised of low growing mixtures of hydroids, bryozoans, anemones, and sponges, etc.), encrusting sponges, anemones, and *Cancer* crabs. Turf abundance ranged from about 25 to almost 100% cover in localized areas, influenced by sediment cover, and was most common at shallower depths (e.g., less than about 60 feet). Seastars were particularly abundant at Harding, Shag, and Arch, from the shallowest depths (35-40 feet) to the deepest extent of rocky substrate (about

70-85 feet). The dominant seastar on these three features was the bat star, *Asterina miniata*, followed by *Pisaster* spp (*P. brevispinus* and *P. ochraceous*). The highest bat star densities ranged from about 1 to 4 per square meter at Harding Rock. The only seastar observed at Blossom Rock was *P. brevispinus*, potentially due to the higher sedimentation and turbidity at this site since this species is more tolerant of these types of conditions. Fish species included pelagic species such as northern anchovy (*Engraulis mordax*) and topsmelt (*Atherinops affinis*), as well as some common demersal species, including lingcod (*Ophiodon elongatus*), rock greenling (*Hexagrammos lagocephalus*), and yellowtail rockfish (*Sebastes flavidus*). In addition, unidentified fish species, similar to topsmelt, were observed over soft-bottom habitats. Overall taxonomic diversity (species richness) ranged from 7 to 12 taxa, limited in part by stressful natural conditions (high turbidity, extensive sediment cover, and strong currents), but also influenced by very poor visibility that partly affected photographic documentation.

2.0 STUDY METHODS

ROV surveys were conducted from September 11 to 15, 2001, at four shallow sites (Harding, Shag, Arch, and Blossom Rocks) and adjacent deeper water depressions in the vicinity of Alcatraz Island in San Francisco Bay (Figure 2-1). Dr. Andrew Lissner of SAIC (San Diego, CA) was the cruise leader and senior scientist, supported by senior scientist Ms. Sue Benech. Both of these scientists have over 25 years experience performing photographic and video surveys of the subtidal hard-bottom habitats and species of California, principally using ROVs, and are experts in the taxonomy and ecology of invertebrates and fish. Mssrs. Tony Haaland and Bob Meek of Ecomar, Inc. (Santa Barbara, CA) coordinated the survey vessel and ROV operations. Crew support was provided by Ms. Brooke Basse and Mssrs. Mitch Grubs, Craig Van Senus, and Scott Wolf of Ecomar. Survey navigation was performed by Mr. Joe Macha of Fugro, Inc. (Ventura, CA). All these activities were under the authorization of Mr. John Garcia of Garcia and Associates (GANDA).

The survey was conducted using a Phantom 2+2 ROV equipped with color scanning Mesotech sonar, color high-resolution video with voice recording capabilities, and a Photosea 35-mm still camera and strobe system. The ROV, owned and operated by Ecomar, is rated for operation in currents up to 3 knots and water depths up to 1,200 feet. The survey vessel, R/V CYPRESS POINT, also owned and operated by Ecomar, is a 65-foot Breaux Bay Craft with an average cruising speed of 17 knots. Fugro provided the navigational systems and services.

The still camera system has a bulk loading capability (e.g., 150+ frames). Both the color video and still camera systems have a data logger showing time and date to allow synchronization with the navigation record, and were capable of “tilting” in order to record data in forward- and downward-looking orientations, as

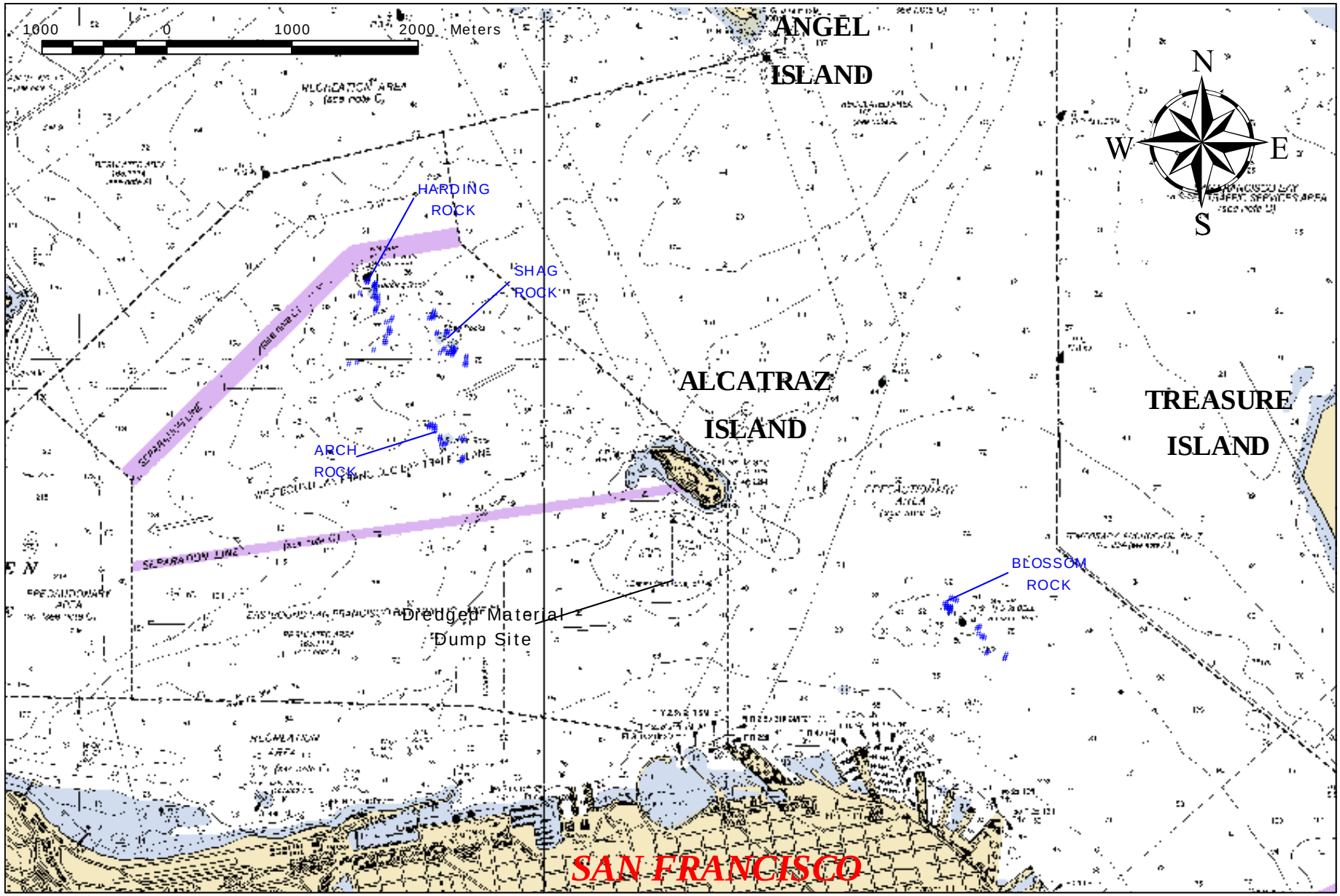

Figure 2-1. General Location of ROV Surveys at Harding, Shag, Arch, and Blossom Rocks, San Francisco Bay, CA, September 2001. Dots show navigational fix points along ROV transects.

appropriate for relatively vertical and relatively flat relief, respectively. A direct depth read-out on the video record was visible for manual recording on the observer logs and navigation record. A standard offset from the still camera to the bottom was accomplished using twin lasers mounted on the ROV. The lasers were angled to converge at a single point when the vehicle reached a distance above the bottom that resulted in a 0.25-meter square viewing area (photoquadrat). This ensured that all photographs taken at this height showed the same surface area for purposes of species density estimates. This surface area also helped optimize data quality due to low water visibility. During the survey, the biologists viewed the bottom using real-time video to target specific features or biological communities and to watch the convergence of the laser beams to indicate the proper time to trigger a still photograph. The color video was used primarily in an oblique- to forward-looking mode.

The biologists tape recorded observations as part of video data collections. Other key information such as survey conditions (weather, wind, seas, tides), habitat types, species, and the timing of still photographs was recorded on log sheets (Appendix A, Observer Logs). Any sightings of fishing activities and marine mammals were also recorded.

Because of extreme tidal currents (e.g., 2-5 knots) that were common in the study area, ROV operations focused around slack tides and predicted lower tidal current velocities associated with the quarter moon phase to minimize tidal influences and optimize data quality. Targeted dates of minimal tidal influence were based on tide-predicting models available from the University of South Carolina website (http://tbone.biol.sc.edu/tide). Other factors that influenced data collection activities in this region included low water visibility, fog, wind, and other vessel traffic. Targeting slack tide conditions during late summer helped to minimize impacts from these environmental factors, and was consistent with other recent studies in the region (e.g., ACOE 2000). Notification and communication were maintained with the San Francisco Vessel Pilot and U.S. Coast Guard. Further, the ship displayed required day shapes to help avoid potential conflicts with other vessels.

The original survey plan was to conduct “live-boat” operations (boat following the ROV progress) along a single transect at each of the four sites, beginning near the base of the rock feature, extending over the summit region, and concluding in the adjacent deeper water depression. As detailed in the Results section, the very strong currents (typically 2 to greater than 3 knots) and poor visibility (e.g., 6 inches to 2 feet) required a different operational method whereby the survey vessel was progressively anchored/re-anchored at different locations along the transect line. The ROV then covered as much area per anchoring location as conditions allowed.

3.0 RESULTS AND DISCUSSION

ROV surveys to characterize the four sites were conducted from September 11 to 15, 2001, with data collection at each site occurring over one to three days to accommodate variable tide and wind conditions (Table 3-1). This “mosaic” of surveys was pieced together by coding the navigational positions (fixes) as sequential numbers for each site (e.g., 1 to 32), thereby providing a coherent data set for analysis and interpretation. Thus, the fix numbers for each revisit of a site began where the previous sequence at that site had ended (Table 3-1). The fixes were then plotted on three-dimensional images of the bathymetry for each rock feature (Figures 3-1 to 3-4) to aid in habitat and biological community evaluations. The site bathymetry images were obtained from U.S. Geological Survey Open File Report 98-139 (Chin et al. 1998) and integrated with the present survey data using a Geographic Information System (GIS).

Wind and sea conditions during the surveys were generally calm (0- to 10-knot winds and less than 2-foot swells and chop) until afternoon when winds typically exceeded 15 knots to as much as 25 knots after about 1300-1400 (Appendix A, Observer Logs). Ocean currents were moderately to very strong during most of the survey, commonly exceeding about 2 knots and frequently 3 knots, representing a combination of tidal and wind influence. These combined factors and the predominant soft-bottom habitat and high load of suspended particulates observed in the study region contributed to extremely poor water visibility (e.g., 6 inches to 2-3 feet) during the survey, particularly in the Blossom Rock area. This poor visibility and strong currents substantially affected survey and data collection methods. In particular, typical ROV operations involve live-boating where the survey vessel follows the ROV movements along a pre-determined course. However, based on the strong currents and afternoon winds experienced during the survey, the only method that allowed reliable data collection was to anchor the vessel near the transect and have the ROV survey as far along the transect as possible from each anchoring location. Using this procedure, the ROV was limited by the reach of the power cable (umbilical), vessel anchor line, and the currents. This produces the “grouped” pattern of survey coverage (numbered fixes) shown in Figures 3-1 to 3-4 and listed along with latitudes and longitudes in Appendix B, Navigational Coordinates. However, based on the similarity of the habitats and biological communities among the sites, these data are appropriate for characterizing the rock features.

Overall data returns include 10 hours of color videotape records, and about 200 color photographs representing a combination of 35-mm and video screen capture photographs. The video screen captures were particularly important since we were able to select the clearest segments from the video record to use in still frame analysis of the habitats and species. In contrast, the poor water visibility and high particulate load limited the use of many 35-mm photographs. Many portions of the video are also limited by these same conditions.

Notwithstanding, the combined data provide an appropriate characterization as noted above.

Analysis consisted of a complete review of all video records, transcribing data on habitats and species by navigational position to characterize and compare the four rock features. The 35-mm and video capture photographs were then analyzed to provide additional details on the number and types of species, abundance, and taxonomic diversity (species richness), where feasible. SAIC biologists contributing to the analysis included Mr. D. Heilprin, Dr. A. Lissner, and Ms. S. Benech. Results are presented by rock feature in Sections 3.1 to 3.4. A synopsis of the habitats and species is provided in Table 3-1, and a comparative list of common species by site is summarized in Table 3-2.

Table 3-1. Summary of ROV Survey Depths, Habitats, and Species at Harding, Shag, Arch, and Blossom Rocks, San Francisco Bay, CA, September 2001.

Site	Date	Fix Point (s)	Depth (ft)	Habitat Type	Common Species (other)
Harding	9/12/01	1-3	95-107	Soft sediments/shell hash	
		4-13	107-84	Soft sediments/shell hash	(Cancer crab)
		14	80	Soft sediments/shell hash	Short-spined sea star Bat star
		15	72	Boulders/large cobble	Bat star (White encrusting sponge) Short-spined sea star Turf
		16	65	Boulders	Bat star
		17	65	Boulders/large cobble	Bat star Short-spined sea star
		18	60	Boulders	Turf Bat star Jewel anemone
		19	60	Boulders	
		20	52	Boulders	Turf Bat star
		21	50	Boulders/large cobble	Turf Bat star
		22	50	Boulders/large cobble	Turf Bat star
		23	48-50	Boulders/large cobble	Turf Bat star (Ochre seastar?) (Anemone - Urticina?)
		24	56	Boulders	Turf Jewel anemone
		25	65	Cobble	(Cancer crab)
		26	59	Cobble	

Table 3-1. Continued.

Site	Date	Fix Point (s)	Depth (ft)	Habitat Type	Common Species (other)
		27	58	Cobble	Turf (Cancer crab) Jewel anemone (Ochre seastar?) (Rockfish - unidentified) (Lingcod?)
		28	49	Boulders	Turf
		29	46	Boulders	Turf (Cancer crab)
		30	43	Boulders	Turf Bat star
		31	53	Boulders	Turf
		32	55	Boulders	Turf
		33	56	Boulders	Turf Jewel anemone
		34	58	Boulders	(Lingcod)
		35	63	Cobble/boulders	(Cancer crab)
		36	65	Cobble	(Anemone – Urticina) (Cancer crab) Turf
		37	63	Cobble	Turf Bat star (Tube worms) (Encrusting sponge)
Shag	9/13/01	1	46	Boulders	Bat star Jewel anemone Turf
		2	46	Boulders	Turf Jewel anemone
		3	46	Boulders	Turf Bat star

Table 3-1. Continued.

Site	Date	Fix Point (s)	Depth (ft)	Habitat Type	Common Species (other)
		4	46	Boulders	Turf Bat star
		5	73	Cobble	Turf (Short-spined sea star?)
		6	70	Cobble/shell hash	
		7	70	Boulders	Turf
		8	71	Boulders	Turf
		9	65	Boulders	Turf
		10	61	Boulders	Turf
		11	80	Hard pan with sediment cover	White encrusting sponge
		12	80	Cobble/sediments	
		13	83	Hard bottom	
		14	68	Boulders	Turf (Anemone - Urticina) Jewel anemone
		15	69	Boulders	Tunicates White encrusters Jewel anemone Turf
		16	84	Boulders	Turf
		17	84	Hard bottom (rock)	
		18	83	Hard bottom (rock)	
		19	78	Hard bottom (rock)	(Cancer crab)
		20	79	Hard bottom (rock)	Bat star
		21	41	ROV off bottom	
		22	46	Boulders	Bat star (Rockfish - juv. yellowtail?)
		23	50	Hard bottom (rock)	(Rockfish - juv. yellowtail?)
		24	75	Boulders	Turf

Table 3-1. Continued.

Site	Date	Fix Point (s)	Depth (ft)	Habitat Type	Common Species (other)
		25	68	Boulders	Turf Bat star Jewel anemone (Rockfish, yellowtail)
		26	66	Boulders	Turf (Rockfish - juv. yellowtail)
		27	65	Boulders	Turf Bat star Jewel anemone (Anemone -Urticina)
		28	91	Soft sediments/shell hash	
		29	92	Soft sediments/shell hash	
		30	89	Soft sediments/shell hash	
		31	98	Soft sediments/shell hash	
		32	99	Soft sediments/shell hash	
	9/15/01	33	51	Boulders	Turf Bat star Jewel anemone White encrusters
		34	56	Boulders	Turf (Ochre seastar)
		35	60	Boulders	Turf Bat star White encrusters
		36	37	Cobble	Bat star
		37	37	Cobble	Bat star
Arch	9/13/01	1	76	Soft sediments/shell hash	
		2	76	Soft sediments/shell hash	
		3	73	Soft sediments/shell hash	
		4	74	Soft sediments/shell hash	
		5	87	Soft sediments/shell hash	

Table 3-1. Continued.

Site	Date	Fix Point (s)	Depth (ft)	Habitat Type	Common Species (other)
		6	88	Soft sediments/shell hash	
		7	89	Soft sediments/shell hash	
		8	41	Cobble/boulder	Turf Bat star
		9	42	Boulder	Turf Bat star
		10	43	Cobble/boulder	Turf
		11	42	Cobble/boulder	Turf Bat star
		12	43	Cobble/boulder	Turf Bat star
		13	41	Boulder/cobble	Turf Bat star
		14	44	Boulder	Turf (Anemone -Urticina)
		15	45	Cobble/boulders	Turf Bat star (worm tubes – Potamilla?)
		16	47	Boulder	Turf (Rock greenling)
		17	45	Boulder	Turf
		18	40	Cobble/boulders	Turf
		19	41	Cobble/boulders	Turf (Cancer crab)
		20	42	Cobble/boulders	Turf
		21	41	Cobble	Bat star
		22	42	Cobble	
		23	41	Boulder	Turf Bat star
	9/14/01	24	75	Soft sediments/shell hash	
		25	76	Soft sediments/shell hash	

Table 3-1. Continued.

Site	Date	Fix Point (s)	Depth (ft)	Habitat Type	Common Species (other)
		26	76	Soft sediments/shell hash	
		27	67	Soft sediments/shell hash	
		28	70	Soft sediments/shell hash	
		29	68	Soft sediments/shell hash	
		30	68	Soft sediments/shell hash	(Unidentified flatfish?)
		31	68	Cobble/boulder	
		32	67	Boulder/cobble	Turf Bat star (Ochre seastar?) (Cancer crab) (Squid?)
		33	62	Boulder/cobble	Bat start (Fish, unidentified)
		34		Boulder	Turf (Cancer crab)
Blossom	9/14/01	1	101	Soft sediments/shell hash	
		2	100	Soft sediments/shell hash	
		3	103	Soft sediments/shell hash	
		4	90	Soft sediments/shell hash	
		5	90	Soft sediments/shell hash	(Short-spined sea star)
		6	97	Soft sediments/shell hash	
		7	97	Soft sediments/cobble	
		8	98	Cobble/boulders	
		9	78	Cobble/boulders	
		10	72	Cobble/boulders	
		11	70	Cobble/boulders	
		12	71	Cobble/boulders	
	9/15/01	13	93	Soft sediments/shell hash	
		14	95	Soft sediments/shell hash	
		15	98	Soft sediments/shell hash	

Table 3-1. Continued.

Site	Date	Fix Point (s)	Depth (ft)	Habitat Type	Common Species (other)
		16	98	Soft sediments/shell hash	
		17	99	Soft sediments/shell hash	
		18	99	Soft sediments/shell hash	
		19	95	Soft sediments/shell hash	
		20	84	Soft sediments/shell hash	
		21	89	Soft sediments/shell hash	
		22	99	Soft sediments/shell hash	
		23	100	Soft sediments/shell hash	
		24	100	Soft sediments/shell hash	
		25	93	Soft sediments/shell hash	
		26	99	Soft sediments/shell hash	(Short-spined sea star)
		27	101	Hard bottom (rock)	

Table 3-2. Taxonomic List from ROV Surveys Conducted in September 2001 at Harding, Shag, Arch, and Blossom Rocks, San Francisco, CA.

Scientific Name	Common Name/Manuscript Name	Rock Feature			
		Harding	Shag	Arch	Blossom
Invertebrates					
	Turf (hydroids, bryozoans, sponges, etc.)	X	X	X	X
Asterina miniata	Bat star	X	X	X	
Cancer spp.	Crab	X	X	X	X
Corynactis californica	Jewel anemone	X	X		
Pisaster brevispinis	Short-spined sea star	X			X
Pisaster ochraceus	Ochre seastar	X	X		
Pisaster sp.	Sea star	X	X	X	
Potamilla?	Worm tubes	X		X	
	Sponge, white encrusting	X	X		
Tunicate, encrusting	Sea squirt		X		
Urticina spp.	Anemone	X	X	X	
Fishes					
Atherinops affinis	Topsmelt (?)				X
Engraulis mordax	Northern anchovy (?)				X
Hexagrammos lagocephalus	Rock greenling			X	
Ophiodon elongatus	Lingcod (?)	X			
Sebastes flavidus	Yellowtail rockfish		X		
	Unidentified fish	X	X	X	X
TOTAL TAXA		**12**	**11**	**8**	**6**

Note that a "?" indicates the most likely identification

3.1 Harding Rock

Survey depths at this site ranged from 43 to 107 feet, with hard-bottom habitats extending to about 72 feet and soft bottom evident below this depth. It was not possible to survey depths shallower than 43 feet due to hazardous conditions related to the permanent marker buoy at Harding Rock (Figure 2-1). The total transect length was about 850 m (Figure 3-1). The principal hard-bottom habitat was comprised of boulders and cobble, while soft bottom areas were predominated by dark, coarse sand to gravel and shell hash. These results are consistent with recent geophysical and bathymetric studies of the four sites conducted by the ACOE, San Francisco District (Chin et al. 1998; ACOE 2000). These studies note that Harding Rock extends about 50 feet above adjacent soft-bottom areas of the Bay to a shallow elevation of 36.4 feet Mean Lower Low Water (MLLW). The top is somewhat flattened with two high spots that extend about 4-6 feet above the surrounding rock. This feature and the other sites represent ridges of bedrock (ACOE 2000) along with substantial areas of cobble and boulders (present survey), and at Harding Rock include several 8-foot high pinnacle areas (ACOE 2000). Based on the present survey there is substantial "dusting" and cover of the rock features with fine-grained sediments, thereby influencing the species characterizing the site. For example, species such as gorgonians (sea fans) and other large filter feeders that might be expected in high current regimes (although in areas of relatively low turbidity) were not observed, likely due to the high loads of sediment particles (high turbidity) present at all the sites.

The hard-bottom biological community at Harding Rock was dominated by seastars, particularly the bat star (*Asterina miniata*), "turf" (representing a low-growing community comprised of complex groups of hydroids, bryozoans, anemones, and sponges), and to a lesser extent the ochre seastar and "pink, short-spined" seastar (*Pisaster ochraceous* and *P. brevispinus*) (Tables 3-1 and 3-2 and Appendix C, Photographic Exhibit Examples). The seastars are apparently feeding on the turf community based on their common co-occurrence, as observed in other hard-bottom habitats (e.g., SLC 2000), and because other common prey items such as molluscs were not evident. Incidental, but occasionally common species include rock crabs (*Cancer* spp.) and anemones (*Urticina* spp.) and the jewel anemone (*Corynactis californica*). Based on estimates from the photographs, the size of most of the seastars and crabs was at least 6 inches (ray [armtip] to ray, and carapace [shell] width, respectively), indicating these were adult specimens. The highest number of seastars was observed at Harding, with maximum bat star densities ranging from about 1 to 4 per square meter, and ochre seastar densities about half these numbers in localized areas. Rock crabs were locally common in densities of about 1 per 100 square meters. Cover of turf ranged from about 25 to 100% in localized areas. Fish were represented by relatively few species including lingcod and an unidentified pelagic schooling species, likely either northern anchovy, topsmelt, or Pacific sardines (Table 3-2). The highest species richness of invertebrate and

fish taxa combined (12) was observed at Harding, although numerous other species are undoubtedly present, limited in documentation by survey conditions of high turbidity and the need to have collected specimens for laboratory confirmation of many small or cryptic species. Nonetheless, the confirmed taxa provide appropriate documentation of the community types.

In contrast to the hard-bottom community, there were no invertebrates observed in the soft-bottom habitats, although this undoubtedly was influenced by the extremely poor visibility in these areas. Only a few unidentified fishes (likely flatfishes) were observed over soft-bottom habitats.

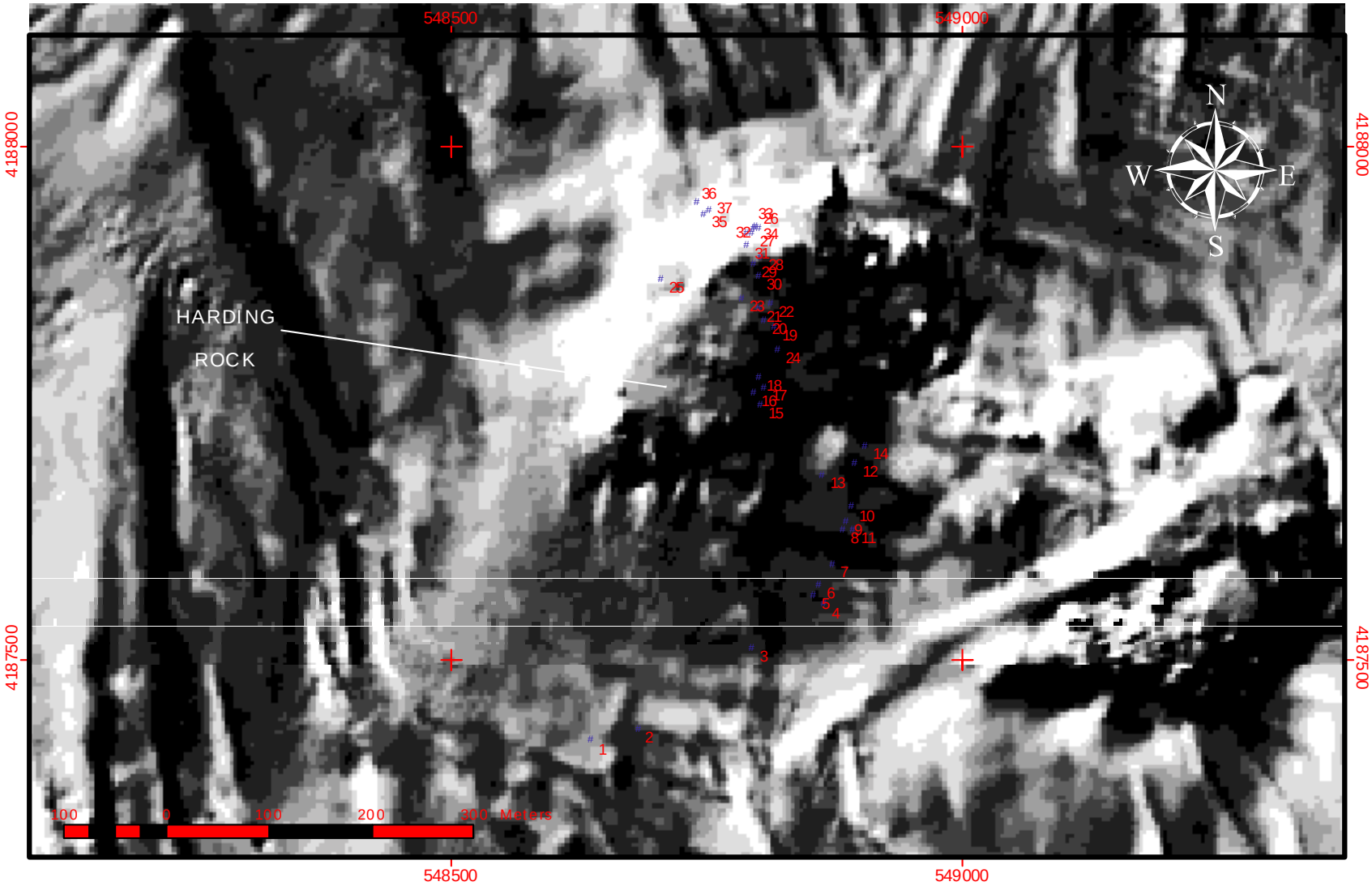

Figure 3 - 1. Location of ROV Surveys at Harding Rock, San Francisco Bay, CA, September, 2001. Numbered dots show navigational fix points as detailed in the appendix.

3.2 Shag Rock

Survey depths at this site ranged from 37 to 99 feet, with hard-bottom habitats extending to about 84 feet and soft bottom occurring below this depth. The total transect length was about 550 m (Figure 3-2). The hard-bottom habitat was typified by cobbles and boulders as noted for Harding, but appeared to have more areas of exposed outcrops and one area (fix point 11) of hard pan overlain by sediments. Soft-bottom areas were predominated by dark, coarse sand to gravel and shell hash, also as noted for Harding. These results are also consistent with recent geophysical and bathymetric studies of the four sites (Chin et al. 1998; ACOE 2000). These studies note that Shag Rock extends about 50 feet above adjacent soft-bottom areas to a shallow elevation of 37.5 feet MLLW. The top is comprised of two flattened mounds separated by a 5-foot depression. As noted for Harding, this feature represents a ridge of bedrock (ACOE 2000) along with substantial areas of cobble and boulders (present survey), and at Shag Rock includes numerous pinnacle areas ranging from 5-20 feet in height (ACOE 2000). Similar to the results for Harding, there is substantial dusting and cover of the rock features with fine-grained sediments, thereby influencing the biological species occurring at the site.

Similar to Harding Rock, the hard-bottom biological community at Shag was dominated by the bat star, turf organisms, and to a lesser extent the ochre seastar (Tables 3-1 and 3-2 and Appendix C). Incidental species included rock crabs and anemones. In general, fewer crabs were observed at Shag than at Harding, with maximum densities of about half the size (e.g., 1 per 200 square meters) in localized areas. Other species also had densities that were about half the abundance noted at Harding, as influenced partly by poorer visibility at Shag, thereby limiting photographic documentation. Based on size estimates from the photographs, most of the seastars and crabs were adults, as noted for Harding. Fish at this site were also represented by relatively few species including yellowtail rockfish and an unidentified pelagic schooling species, likely either northern anchovy, topsmelt, or Pacific sardines, as noted for Harding (Table 3-2). Shag had the second highest taxonomic diversity of invertebrate and fish taxa combined (11 versus 12 at Harding). As discussed above, numerous other species are undoubtedly present, but the confirmed taxa provide appropriate documentation of the community types.

As noted for Harding, no invertebrates were observed and only a few unidentified fishes (likely flatfishes) were recorded in the soft-bottom habitats.

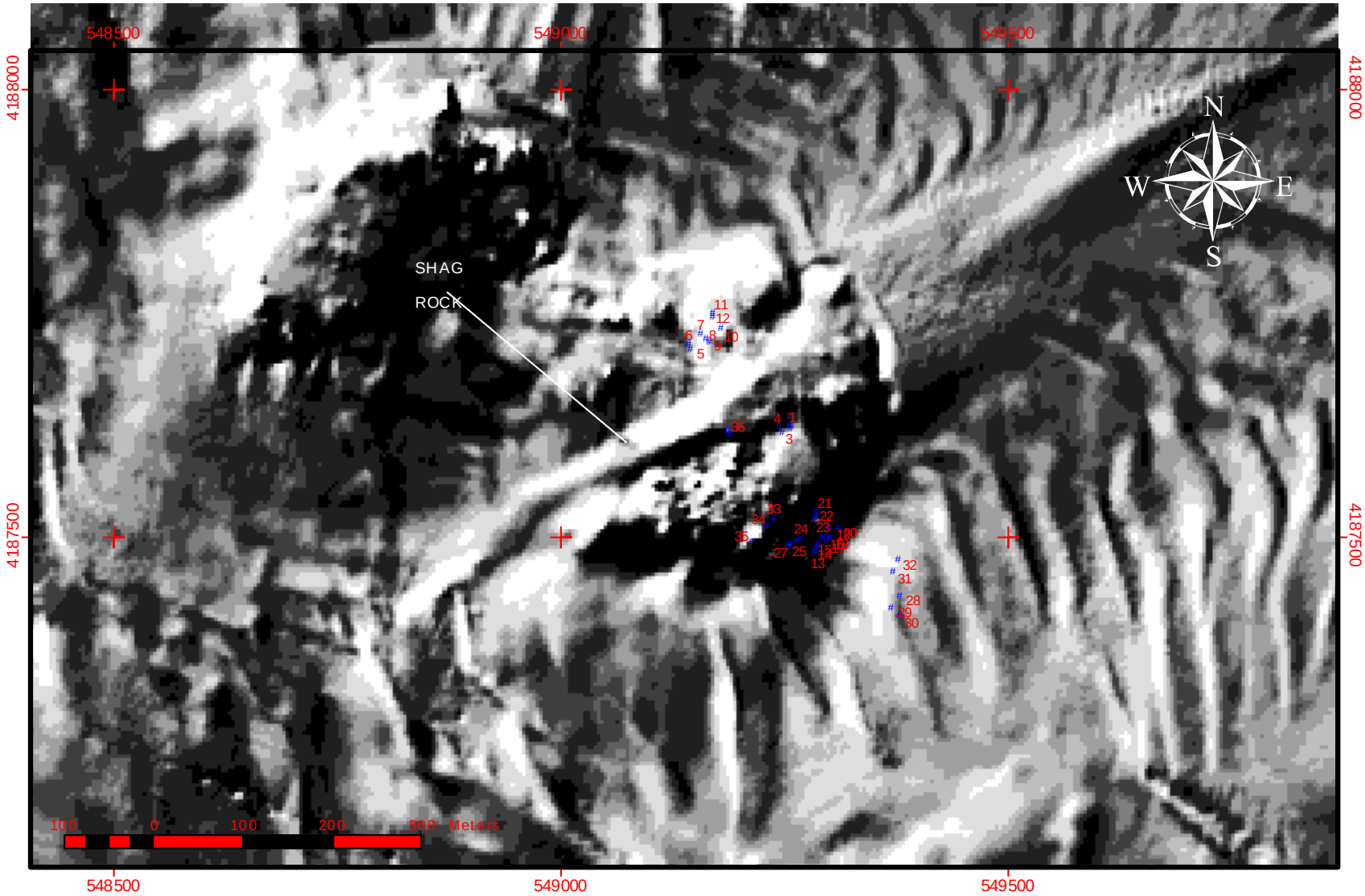

Figure 3 - 2. Location of ROV Surveys at Shag Rock, San Francisco Bay, CA, September, 2001. Numbered dots show navigational fix points as detailed in the appendix.

3.3 Arch Rock

Survey depths at this site ranged from 41 to 89 feet, with hard-bottom habitats documented to at least 68 feet and likely to 70 to 80 feet, based on results from ACOE (2000). Soft bottom was documented from about 70 to 89 feet. The total transect length was about 600 m (Figure 3-3). The principal hard-bottom habitat was characterized by cobbles and boulders, similar to Harding and many areas of Shag. Soft-bottom areas were predominated by dark, coarse sand to gravel and shell hash, also as noted for Harding and Shag. These results are also consistent with recent geophysical and bathymetric studies of the four sites (Chin et al. 1998; ACOE 2000). These studies note that Arch Rock extends about 40 feet above adjacent soft-bottom areas to a shallow elevation of 36 feet MLLW. The top is generally flattened with several small peaks and boulders about 2 feet high. Similar to the other features, this area represents a ridge of bedrock (ACOE 2000) along with substantial areas of cobble and boulders (present survey). As noted for the other rocks, there is substantial dusting and cover of the feature with fine-grained sediments, thereby influencing the biological species occurring at the site.

The hard-bottom biological community at Arch was dominated by the bat star, turf organisms, and to a lesser extent the ochre seastar (Tables 3-1 and 3-2 and Appendix C). Incidental species included rock crabs and anemones. Similar to the results for Shag, fewer crabs and lower overall densities for other taxa were observed at Arch compared to Harding. Based on size estimates from the photographs, most of the seastars and crabs were adults, as noted for Harding and Shag. Similar to the other sites, fish were represented by relatively few species including rock greenling, topsmelt, and the same unidentified pelagic schooling species (Table 3-2). These species are likely either northern anchovy, topsmelt, or Pacific sardines. Arch was typified by moderate taxonomic diversity of invertebrates and fish combined (8 versus 12 and 11 at Harding and Shag, respectively). However, as discussed above, numerous other species are undoubtedly present, and the confirmed taxa provide appropriate documentation of the community types.

As noted for Harding and Shag, there were no invertebrates observed in the soft-bottom habitats. As summarized for the other sites, only a few unidentified fishes (likely flatfishes) were observed over soft-bottom habitats.

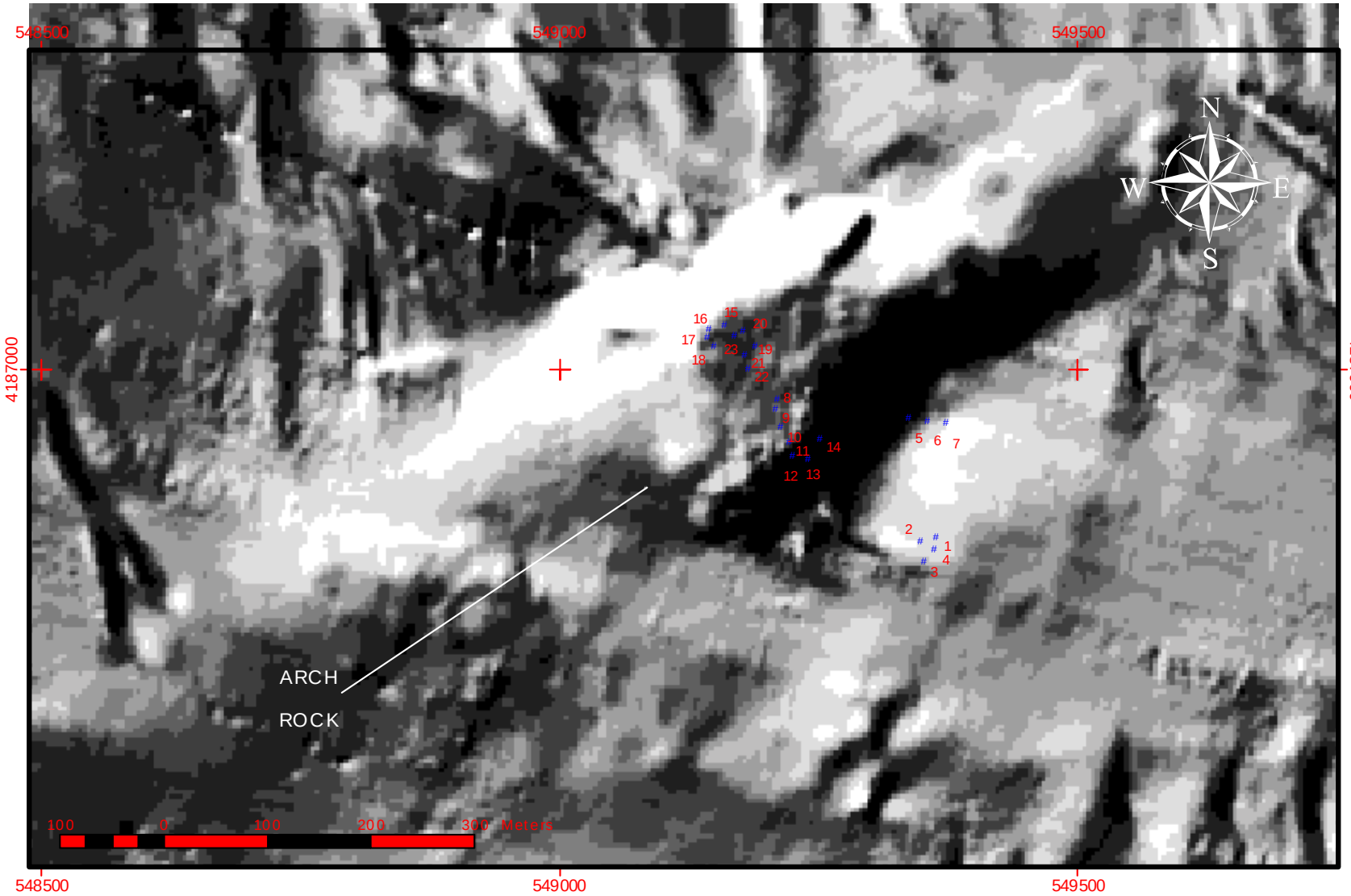

Figure 3 - 3. Location of ROV Surveys at Arch Rock, San Francisco Bay, CA, September, 2001. Numbered dots show navigational fix points as detailed in the appendix.

3.4 Blossom Rock

Survey depths at this site ranged from 70 to 103 feet, with at least some scattered areas of hard-bottom habitat extending to 101 feet. Soft bottom was observed in some areas from 84 to 103 feet. It was not possible to survey depths shallower than 70 feet due to hazardous conditions related to the permanent marker buoy at Blossom Rock (Figure 2-1) and very strong tidal currents and poor visibility at this site. The total transect length was about 650 m (Figure 3-4). The principal hard-bottom habitat was characterized by cobbles and boulders as noted for the other sites. Soft bottom areas were predominated by dark, coarse sand to gravel and shell hash, also as noted for the other sites. These results are also consistent with recent geophysical and bathymetric studies of the four sites (Chin et al. 1998; ACOE 2000). These studies note that Blossom Rock extends about 50 feet above adjacent soft-bottom areas of the Bay to a shallow elevation of about 40 feet MLLW. The top is generally flattened. As noted for the other sites, this feature represents a ridge of bedrock (ACOE 2000) along with substantial areas of cobble and boulders (present survey). Compared to the other sites, Blossom appeared to have more cover of the rock features by fine-grained sediments likely influencing the smaller biological species occurring at the site.

The hard-bottom biological community at Blossom was only represented by three species in low abundance: pink, short-spined seastar, rock crab, and turf. This appeared to be related to the comparatively higher levels of sediment cover and turbidity at this site compared to Harding, Shag, and Arch, and may limit the occurrence of other species that are less tolerant of these conditions (see Section 3.5; Ricketts et al. 1968; Smith and Carlton 1975). However, the very poor visibility and marginal survey conditions undoubtedly limited data collections at this site, and apparent densities of even turf organisms were less than half of the abundance seen at Shag and Arch. As summarized for the other sites, fish were represented by relatively few species including topsmelt and northern anchovy (Table 3-2). The unidentified pelagic schooling species were likely either northern anchovy, topsmelt, or Pacific sardines. Blossom had the lowest taxonomic diversity of invertebrate and fish taxa combined (7 versus 8-12 at the other sites). However, as discussed above, other species may be present, and the confirmed taxa provide appropriate documentation of the community types.

As noted for Harding and Shag, there were no invertebrates observed in the soft-bottom habitats. As noted for the other sites, only a few unidentified fishes (likely flatfishes) were observed over soft-bottom habitats.

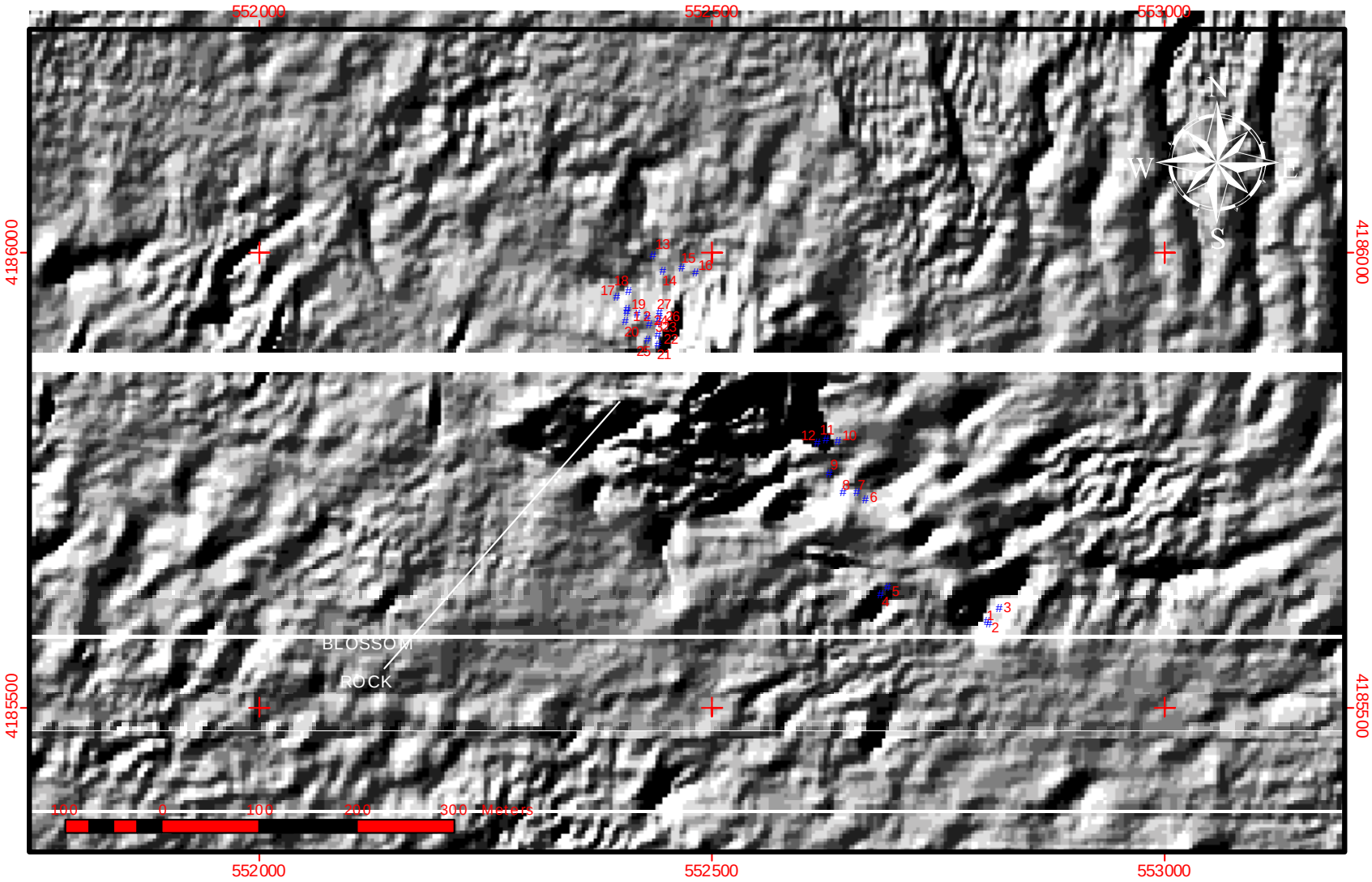

Figure 3 - 4. Location of ROV Surveys at Blossom Rock, San Francisco Bay, CA, September, 2001. Numbered dots show navigational fix points as detailed in the appendix.

3.5 Comparison to Regional Hard-Bottom Habitats

The exposed hard-bottom features characterizing Harding, Shag, Arch, and Blossom Rocks represent relatively isolated "islands" of habitat that are uncommon in the overall San Francisco Bay region. Further, many of the common organisms such as the bat star, turf organisms, and ochre seastar likely colonized the rocky areas by way of planktonic larvae, since the adults are either incapable of movement (sessile/attached turf species) or generally avoid soft-bottom areas due to anatomical limitations (e.g., the attachment tube feet of the bat star and ochre seastar allow strong attachment on hard substrate, but are ineffective or may become clogged when moving across soft bottom). Therefore, once an individual colonizes these features via the plankton, they are unlikely to move (or be able to move) across intervening soft-bottom areas to occupy another hard-bottom feature. This may explain the high abundance of predominantly hard-bottom seastars on Harding, Arch, and Shag Rocks: densities of these species may continue to increase over time as a result of planktonic larvae, within the carrying capacity of food resources on each isolated feature. Similar patterns of high densities of hard-bottom seastars on isolated rock features have been observed off the central California coast (Lissner et al. 1991). Other species such as the *Cancer* crab and pink, short-spined seastar are characteristic of both hard and soft-bottom substrates and could disperse more readily among features. It is notable that on Blossom Rock the only seastar observed was the pink, short-spined species. This may be related to the higher sediment cover and turbidity on this feature as compared to Harding, Shag, and Arch, although the visibility was so poor it is possible that other species were not documented.

Another factor that may influence turbidity in the survey region is the continued use of the dredged material disposal site (Site 11), located south of Alcatraz Island (circular site in Figure 2-1). By intent, this is a dispersive site that has received dredged material from many sites in the Bay since 1894, and was being used during much of the present survey. This may partly affect water clarity at the four rock features, depending on current direction and strength, but likely does not exceed the overall influence of sediment and particle movement from other parts of the Bay on this local environment. Data are not available on differences in turbidity and sediment transport in the study region, such as might clarify differences at Blossom Rock (higher turbidity and currents) during the survey, however, outflow from South Bay past the Blossom region would be a good subject for future study (J. Gartner and D. Schoelhamer, USGS, Menlo Park and Sacramento, respectively, personal communication, 2001).

The biological communities of the rock features are similar to other hard-bottom marine habitats at comparable depths in the central California coastal region (e.g., BLM 1978; SLC 2000; personal observations), although abundance of the bat star and ochre star is generally higher, particularly at Harding. However,

within the overall San Francisco Bay region, rock features and associated species of this type are an uncommon resource.

No marine mammals were observed during the survey. Fishing vessels included the recreational party boat NEW KEESA that was fishing near Harding Rock for a couple of hours on 9/12/01, and two unidentified small (e.g., less than 40 feet long) commercial vessels that transited through the area.

4.0 CONCLUSIONS

In general, the habitats at Harding, Shag, Arch, and Blossom rocks are typified by boulders and cobble overlaying rocky reef features from the shallowest depths (35-40 feet) to about 70 to 80-100 feet depending on the site. Below these depths the substrate grades into coarse sand and gravel that commonly is dark color, interspersed with shell debris. Fine-grained sediments cover most of the hard bottom areas, consistent with the very high levels of turbidity that were present during the entire survey, and which are typical of San Francisco Bay waters. The combination of fine-grained sediments in many parts of the Bay and the strong currents (e.g., 2 to more than 3 knots) likely contribute to the high particle loads, particularly at Blossom Rock, compared to the other sites.

The biological communities observed on the four rock features are consistent with those at similar depths in many hard-bottom marine habitats of the central California coast. However, these represent relatively isolated “islands” of habitat that are uncommon in the overall San Francisco Bay region. The most common species on each of the four features were seastars, “turf” organisms (comprised of low growing mixtures of hydroids, bryozoans, anemones, and sponges, etc.), encrusting sponges, and Rock crabs (*Cancer* spp.). Seastars were particularly abundant at Harding (locally from 1 to 4 per square meter), and also at Shag and Arch but in reduced numbers, from the shallowest depths (35-40 feet) to the deepest extent of rocky substrate. The dominant seastar on these three features was the bat star (*Asterina miniata*), followed by *Pisaster* spp (*P. brevispinus* and *P. ochraceous*). Rock crabs were most abundant at Harding Rock (e.g., locally to about 1 per 100 square meters). Turf abundance ranged from about 25 to almost 100% cover in localized areas, influenced by sediment cover, and was most common at shallower depths (e.g., less than about 60 feet). Incidental invertebrate species on all but Blossom Rock included anemones (*Urticina* spp. and the jewel anemone (*Corynactis californica*). The only seastar observed at Blossom Rock was *P. brevispinus*, potentially due to the apparently higher sedimentation and turbidity at this site since this species is more tolerant of these conditions (e.g., Smith and Carlton 1975). Relatively few fish species were observed at the rock features, mainly due to the poor visibility during the surveys. The fishes that were observed, including lingcod, rock greenling, and yellowtail rockfish (Table 3-2), are typical of rocky areas at similar depths throughout the region. Some pelagic schooling fishes and bottom-dwelling fishes (likely halibut) that could not be identified to species were observed in the water column and

over soft-bottom habitats. Overall taxonomic diversity (species richness) was low (7-12) compared to many hard-bottom areas of similar depth. Diversity and abundance are limited in part by stressful natural conditions (high turbidity, sediment cover, and strong currents), but also influenced by very poor visibility that limited photographic documentation.

5.0 REFERENCES

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APPENDIX A

OBSERVER LOGS
FOR ALCATRAZ SURVEY

(insert hard copies of Observer Log sheets)

APPENDIX B

NAVIGATIONAL COORDINATES FOR ALCATRAZ SURVEY

Appendix B. Navigational Coordinates for ROV Surveys of Harding, Shag, Arch, and Blossom Rocks, San Francisco Bay, CA, September 11-15, 2001.

Waypoint	Date	Time	Latitude	Longitude
		Harding Rock		
1	9/12/01	8:50:34	37° 49.97' N	122° 26.83' W
2	9/12/01	8:53:34	37° 49.98' N	122° 26.80' W
3	9/12/01	9:05:34	37° 50.02' N	122° 26.72' W
4	9/12/01	9:12:25	37° 50.04' N	122° 26.68' W
5	9/12/01	9:14:11	37° 50.05' N	122° 26.68' W
6	9/12/01	9:14:42	37° 50.05' N	122° 26.68' W
7	9/12/01	9:18:19	37° 50.06' N	122° 26.67' W
8	9/12/01	9:22:05	37° 50.08' N	122° 26.66' W
9	9/12/01	9:22:44	37° 50.08' N	122° 26.66' W
10	9/12/01	9:24:01	37° 50.09' N	122° 26.66' W
11	9/12/01	9:27:54	37° 50.08' N	122° 26.66' W
12	9/12/01	9:34:04	37° 50.12' N	122° 26.66' W
13	9/12/01	9:39:23	37° 50.11' N	122° 26.68' W
14	9/12/01	9:44:45	37° 50.13' N	122° 26.65' W
15	9/12/01	9:53:16	37° 50.15' N	122° 26.72' W
16	9/12/01	9:56:28	37° 50.15' N	122° 26.72' W
17	9/12/01	10:01:58	37° 50.16' N	122° 26.72' W
18	9/12/01	10:03:54	37° 50.16' N	122° 26.72' W
19	9/12/01	10:13:45	37° 50.19' N	122° 26.71' W
20	9/12/01	10:15:19	37° 50.19' N	122° 26.71' W
21	9/12/01	10:24:02	37° 50.20' N	122° 26.72' W
22	9/12/01	10:32:41	37° 50.20' N	122° 26.71' W
23	9/12/01	10:41:05	37° 50.20' N	122° 26.73' W
24	9/12/01	11:56:37	37° 50.18' N	122° 26.71' W
25	9/12/01	12:02:27	37° 50.21' N	122° 26.78' W
26	9/12/01	14:09:01	37° 50.24' N	122° 26.72' W
27	9/12/01	14:10:36	37° 50.24' N	122° 26.72' W
28	9/12/01	14:16:29	37° 50.23' N	122° 26.72' W
29	9/12/01	14:18:25	37° 50.22' N	122° 26.72' W
30	9/12/01	14:19:50	37° 50.22' N	122° 26.72' W
31	9/12/01	14:31:33	37° 50.23' N	122° 26.73' W
32	9/12/01	14:35:18	37° 50.24' N	122° 26.73' W
33	9/12/01	14:36:48	37° 50.24' N	122° 26.72' W
34	9/12/01	14:39:48	37° 50.24' N	122° 26.72' W
35	9/15/01	12:22:30	37° 50.25' N	122° 26.75' W
36	9/15/01	12:23:48	37° 50.25' N	122° 26.76' W
37	9/15/01	12:27:44	37° 50.25' N	122° 26.75' W
		Shag Rock		
1	9/13/01	6:39:51	37° 50.08' N	122° 26.41' W
2	9/13/01	6:47:52	37° 50.08' N	122° 26.41' W

Appendix B. Continued.

Waypoint	Date	Time	Latitude	Longitude
3	9/13/01	6:57:39	37° 50.07’ N	122° 26.42’ W
4	9/13/01	7:00:19	37° 50.08’ N	122° 26.42’ W
5	9/13/01	7:42:24	37° 50.13’ N	122° 26.48’ W
6	9/13/01	7:52:25	37° 50.13’ N	122° 26.49’ W
7	9/13/01	7:54:57	37° 50.13’ N	122° 26.48’ W
8	9/13/01	7:56:39	37° 50.13’ N	122° 26.47’ W
9	9/13/01	7:58:53	37° 50.13’ N	122° 26.47’ W
10	9/13/01	8:06:15	37° 50.14’ N	122° 26.46’ W
11	9/13/01	8:13:23	37° 50.15’ N	122° 26.47’ W
12	9/13/01	8:17:33	37° 50.14’ N	122° 26.47’ W
13	9/13/01	9:07:44	37° 50.00’ N	122° 26.39’ W
14	9/13/01	9:09:44	37° 50.00’ N	122° 26.39’ W
15	9/13/01	9:13:35	37° 50.01’ N	122° 26.39’ W
16	9/13/01	9:17:55	37° 50.01’ N	122° 26.38’ W
17	9/13/01	9:18:50	37° 50.01’ N	122° 26.38’ W
18	9/13/01	9:20:07	37° 50.01’ N	122° 26.38’ W
19	9/13/01	9:27:54	37° 50.02’ N	122° 26.38’ W
20	9/13/01	9:33:29	37° 50.02’ N	122° 26.37’ W
21	9/13/01	11:09:52	37° 50.03’ N	122° 26.39’ W
22	9/13/01	11:11:05	37° 50.02’ N	122° 26.39’ W
23	9/13/01	11:13:26	37° 50.02’ N	122° 26.39’ W
24	9/13/01	11:17:10	37° 50.01’ N	122° 26.40’ W
25	9/13/01	11:20:12	37° 50.01’ N	122° 26.41’ W
26	9/13/01	11:23:15	37° 50.01’ N	122° 26.41’ W
27	9/13/01	11:25:39	37° 50.01’ N	122° 26.41’ W
28	9/13/01	12:19:35	37° 49.98’ N	122° 26.33’ W
29	9/13/01	12:24:27	37° 49.97’ N	122° 26.33’ W
30	9/13/01	12:26:45	37° 49.96’ N	122° 26.33’ W
31	9/13/01	12:31:53	37° 49.99’ N	122° 26.33’ W
32	9/13/01	12:36:21	37° 50.00’ N	122° 26.33’ W
33	9/15/01	13:19:19	37° 50.02’ N	122° 26.42’ W
34	9/15/01	13:21:36	37° 50.02’ N	122° 26.43’ W
35	9/15/01	13:29:03	37° 50.01’ N	122° 26.44’ W
36	9/15/01	14:55:29	37° 50.08’ N	122° 26.46’ W
37	9/15/01	14:58:25	37° 50.07’ N	122° 26.45’ W
		Arch Rock		
1	9/13/01	13:24:59	37° 49.65’ N	122° 26.34’ W
2	9/13/01	13:29:17	37° 49.65’ N	122° 26.35’ W
3	9/13/01	13:34:04	37° 49.64’ N	122° 26.35’ W
4	9/13/01	13:39:36	37° 49.65’ N	122° 26.34’ W
5	9/13/01	14:24:49	37° 49.72’ N	122° 26.36’ W
6	9/13/01	14:27:50	37° 49.71’ N	122° 26.34’ W
7	9/13/01	14:32:10	37° 49.71’ N	122° 26.33’ W

Appendix B. Continued.

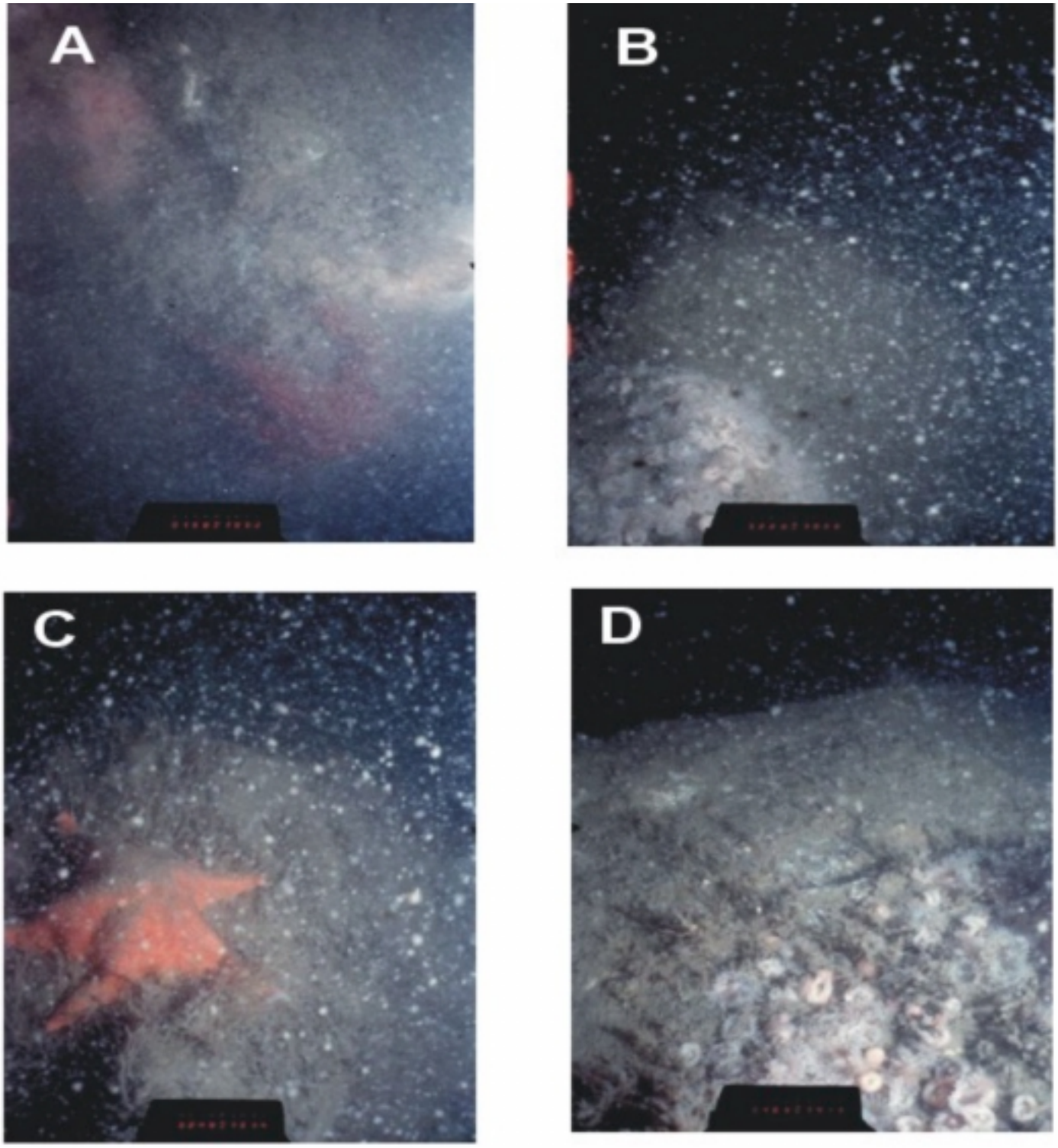
Waypoint	Date	Time	Latitude	Longitude
8	9/13/01	14:58:44	37° 49.73’ N	122° 26.44’ W
9	9/13/01	15:00:09	37° 49.72’ N	122° 26.44’ W
10	9/13/01	15:02:52	37° 49.71’ N	122° 26.44’ W
11	9/13/01	15:04:39	37° 49.70’ N	122° 26.44’ W
12	9/13/01	15:06:50	37° 49.70’ N	122° 26.43’ W
13	9/13/01	15:12:19	37° 49.70’ N	122° 26.42’ W
14	9/13/01	15:15:54	37° 49.71’ N	122° 26.42’ W
15	9/13/01	15:45:00	37° 49.76’ N	122° 26.48’ W
16	9/13/01	15:48:28	37° 49.76’ N	122° 26.49’ W
17	9/13/01	15:54:09	37° 49.76’ N	122° 26.49’ W
18	9/13/01	15:55:52	37° 49.75’ N	122° 26.48’ W
19	9/13/01	15:56:46	37° 49.75’ N	122° 26.46’ W
20	9/13/01	15:59:04	37° 49.76’ N	122° 26.47’ W
21	9/13/01	16:00:49	37° 49.75’ N	122° 26.46’ W
22	9/13/01	16:01:30	37° 49.74’ N	122° 26.46’ W
23	9/13/01	16:03:36	37° 49.76’ N	122° 26.47’ W
		Blossom Rock		
1	9/11/01	12:57:00	37° 48.98’ N	122° 24.02’ W
2	9/11/01	12:59:19	37° 48.97’ N	122° 24.01’ W
3	9/11/01	13:04:04	37° 48.98’ N	122° 24.01’ W
1	9/14/01	15:31:56	37° 49.15’ N	122° 24.27’ W
2	9/14/01	15:34:08	37° 49.15’ N	122° 24.26’ W
3	9/14/01	15:34:47	37° 49.14’ N	122° 24.25’ W
4	9/14/01	15:39:36	37° 48.99’ N	122° 24.09’ W
5	9/14/01	15:39:00	37° 48.99’ N	122° 24.08’ W
6	9/14/01	15:38:21	37° 49.04’ N	122° 24.10’ W
7	9/14/01	15:38:04	37° 49.05’ N	122° 24.11’ W
8	9/14/01	15:37:47	37° 49.05’ N	122° 24.11’ W
9	9/14/01	15:37:23	37° 49.06’ N	122° 24.12’ W
10	9/14/01	15:36:53	37° 49.08’ N	122° 24.12’ W
11	9/14/01	15:36:26	37° 49.08’ N	122° 24.13’ W
12	9/14/01	15:36:09	37° 49.08’ N	122° 24.13’ W
13	9/15/01	6:36:52	37° 49.18’ N	122° 24.25’ W
14	9/15/01	6:44:45	37° 49.17’ N	122° 24.24’ W
15	9/15/01	6:50:27	37° 49.17’ N	122° 24.23’ W
16	9/15/01	6:55:18	37° 49.17’ N	122° 24.22’ W
17	9/15/01	8:24:09	37° 49.16’ N	122° 24.27’ W
18	9/15/01	8:27:13	37° 49.16’ N	122° 24.26’ W
19	9/15/01	8:32:50	37° 49.15’ N	122° 24.27’ W
20	9/15/01	8:35:15	37° 49.14’ N	122° 24.27’ W
21	9/15/01	10:35:22	37° 49.13’ N	122° 24.24’ W
22	9/15/01	10:38:02	37° 49.14’ N	122° 24.24’ W
23	9/15/01	10:38:58	37° 49.14’ N	122° 24.24’ W

Appendix B. Continued.

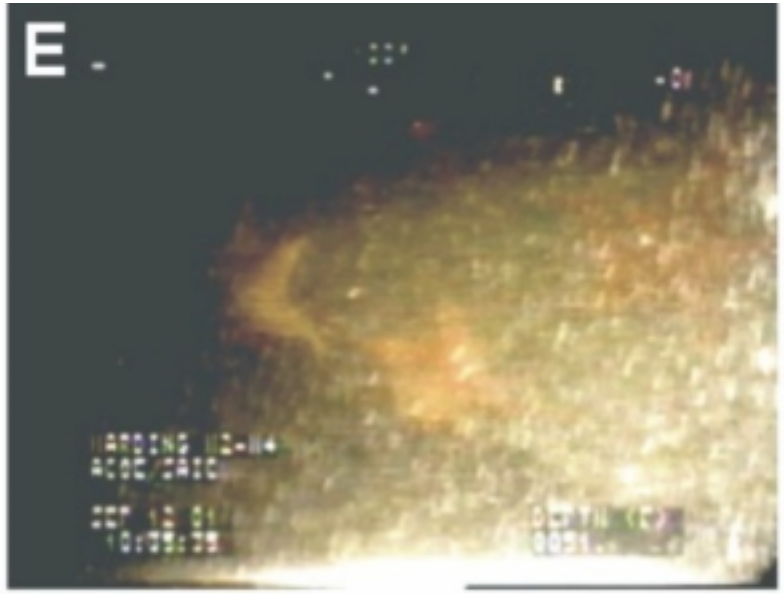
Waypoint	Date	Time	Latitude	Longitude
24	9/15/01	10:40:51	37° 49.15’ N	122° 24.25’ W
25	9/15/01	10:51:10	37° 49.13’ N	122° 24.25’ W
26	9/15/01	10:54:27	37° 49.15’ N	122° 24.24’ W
27	9/15/01	10:57:03	37° 49.15’ N	122° 24.24’ W

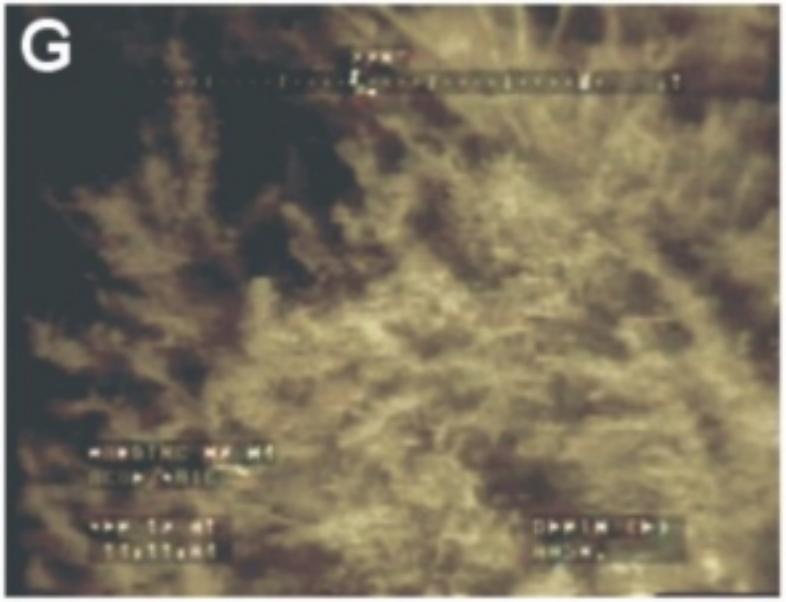
APPENDIX C

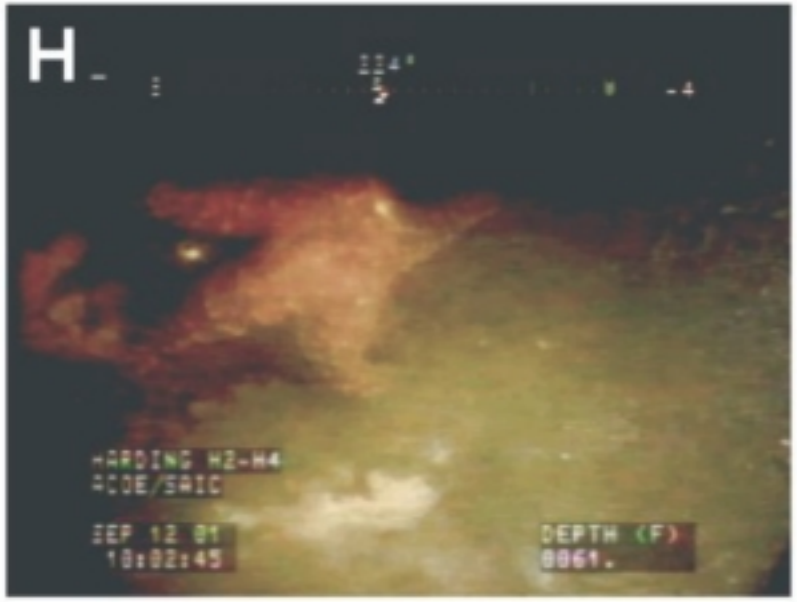
PHOTOGRAPHIC EXHIBIT EXAMPLES FOR ALCATRAZ SURVEY



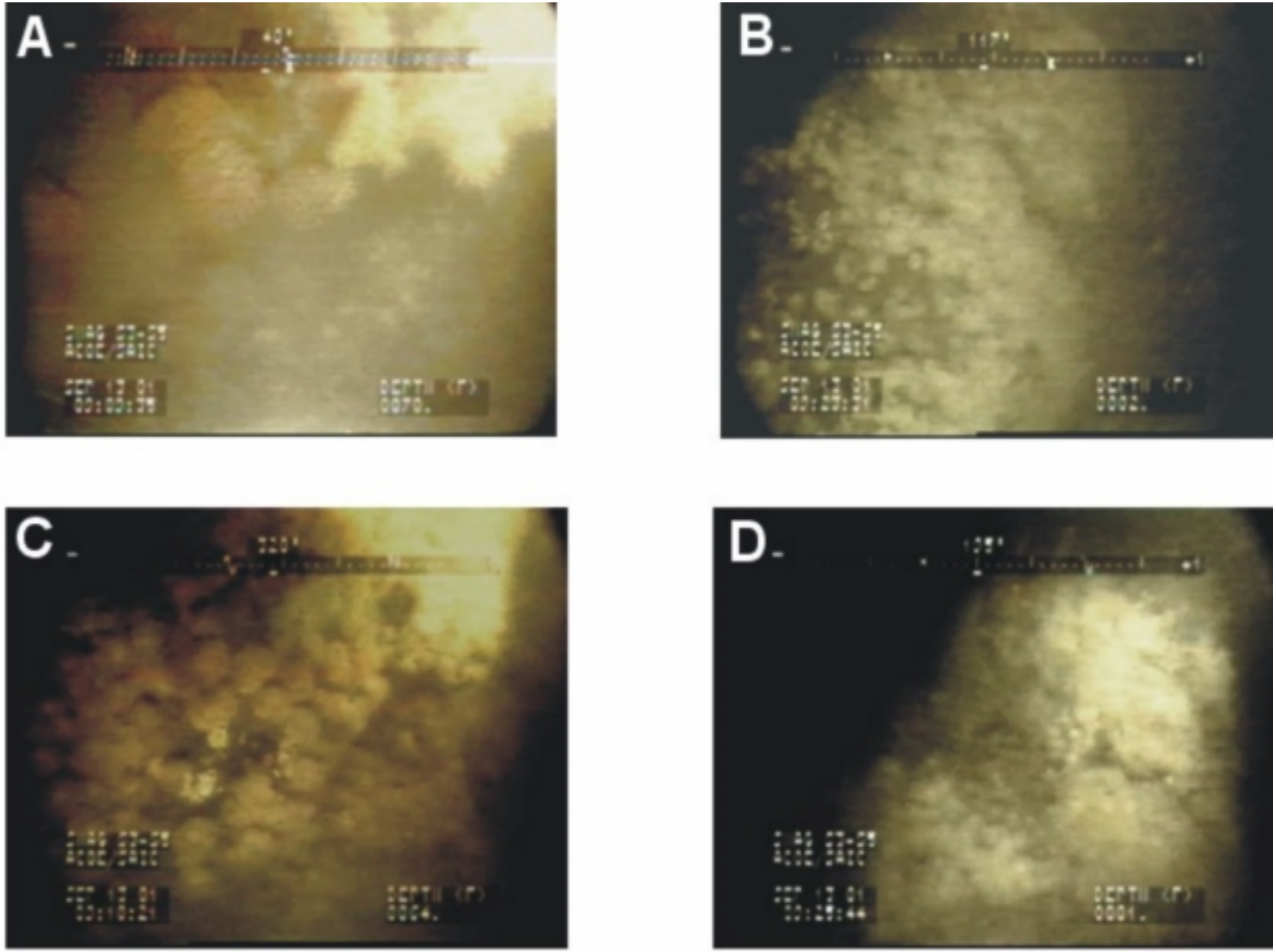
Photographic Examples from ROV Survey of Harding Rock, September 2001. Marine biological organisms include A) Ochre seastar and turf (fix 17, 63 ft); B) Jewel anemones and turf (fix 18, 60 ft); C) Bat star and turf (fix 20, 52 ft); and D) Jewel anemones and turf (fix 27, 56 ft).



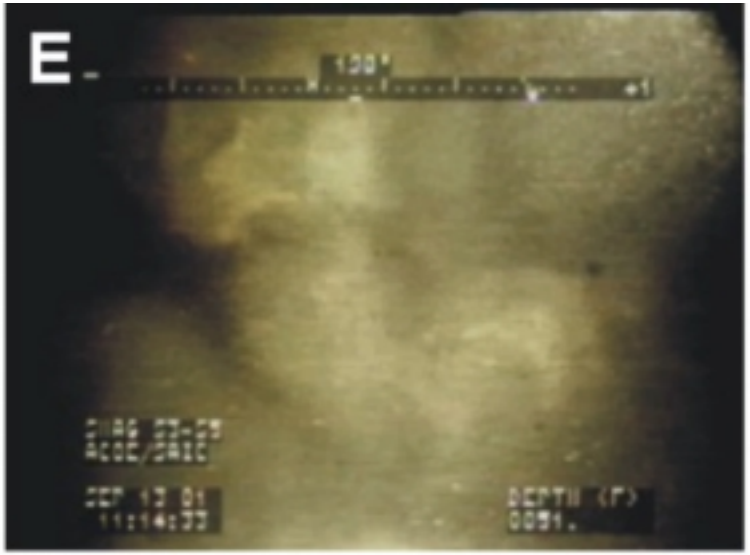


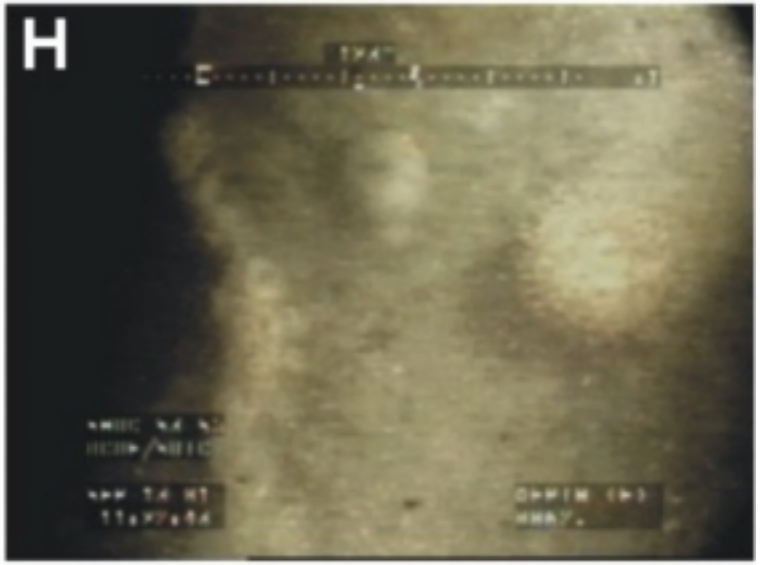


Photographic Examples from ROV Survey of Harding Rock, September 2001. Marine biological organisms include E) Bat star and turf (fix 22, 51 ft); F) Cancer crab and turf (fix 13, 86 ft); G) Turf (fix 27, 56 ft); and H) Ochre seastar and turf (fix 18, 61 ft).

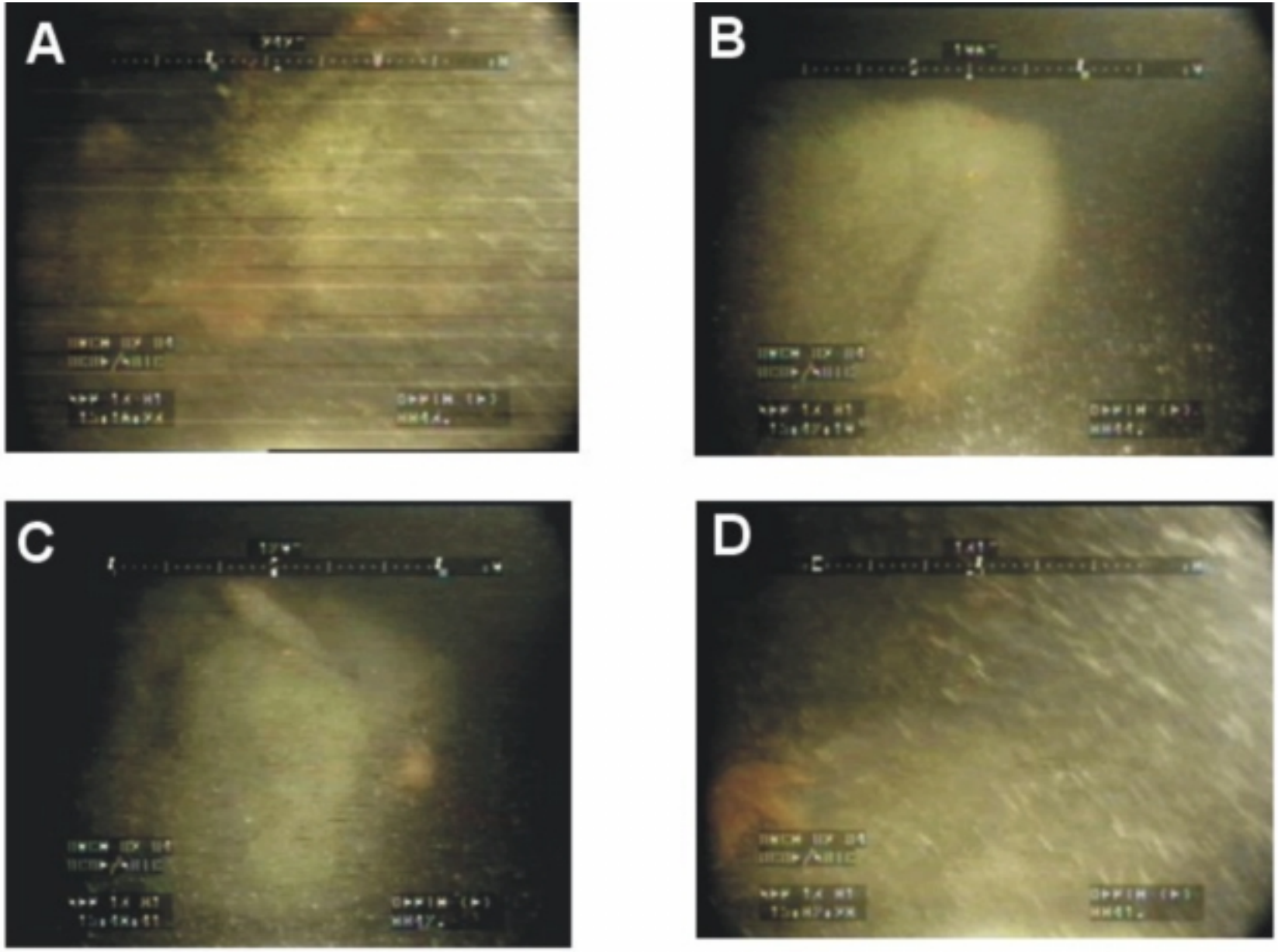


Photographic Examples from ROV Survey of Shag Rock, September 2001. Marine biological organisms include A) Anemone - *Urticina* and turf (fix 14, 70 ft); B) Jewel anemones and turf (fix 18, 82 ft); C) Jewel anemones and turf (fix 14, 64 ft); and D) Jewel anemones and turf (fix 18, 81 ft).

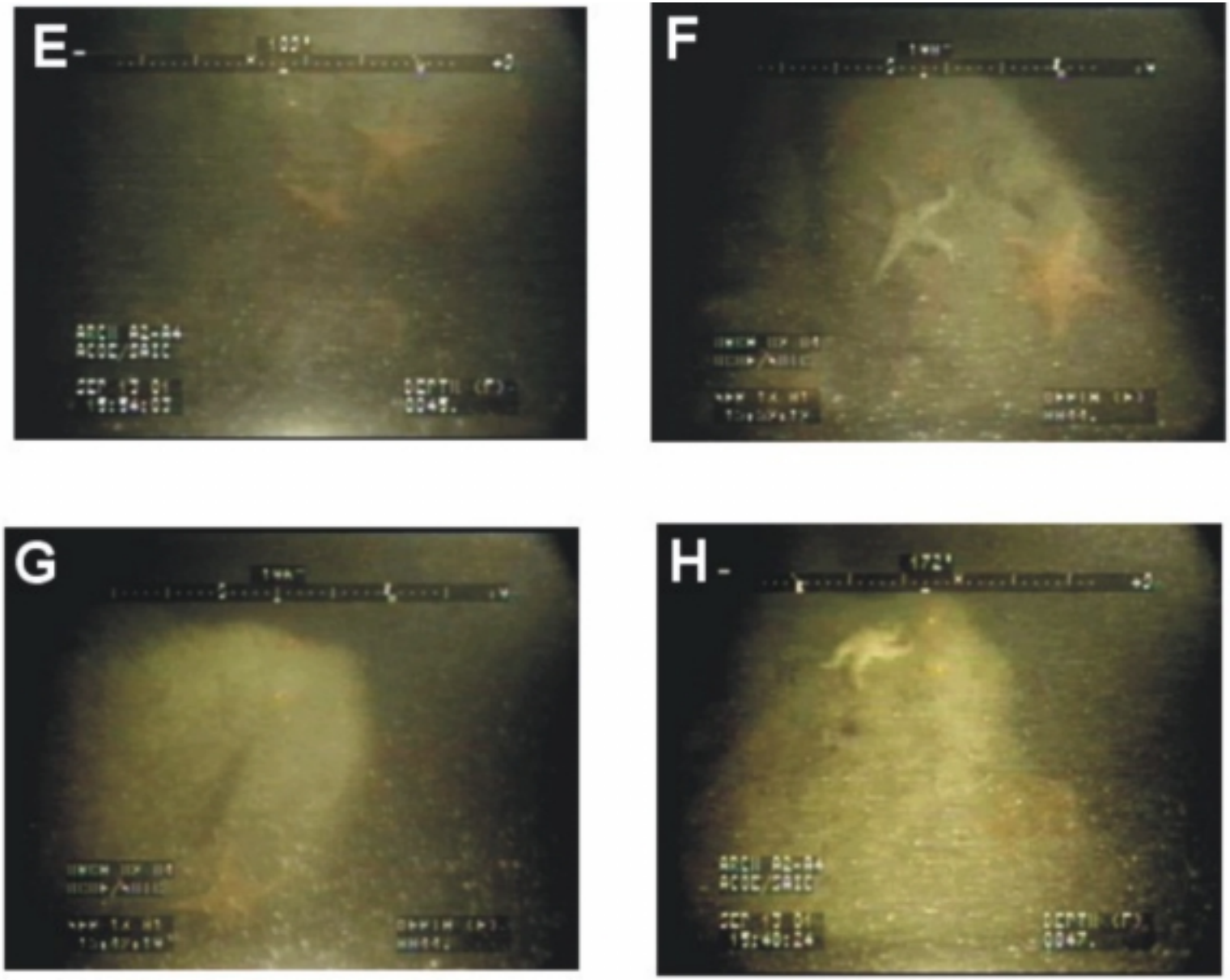




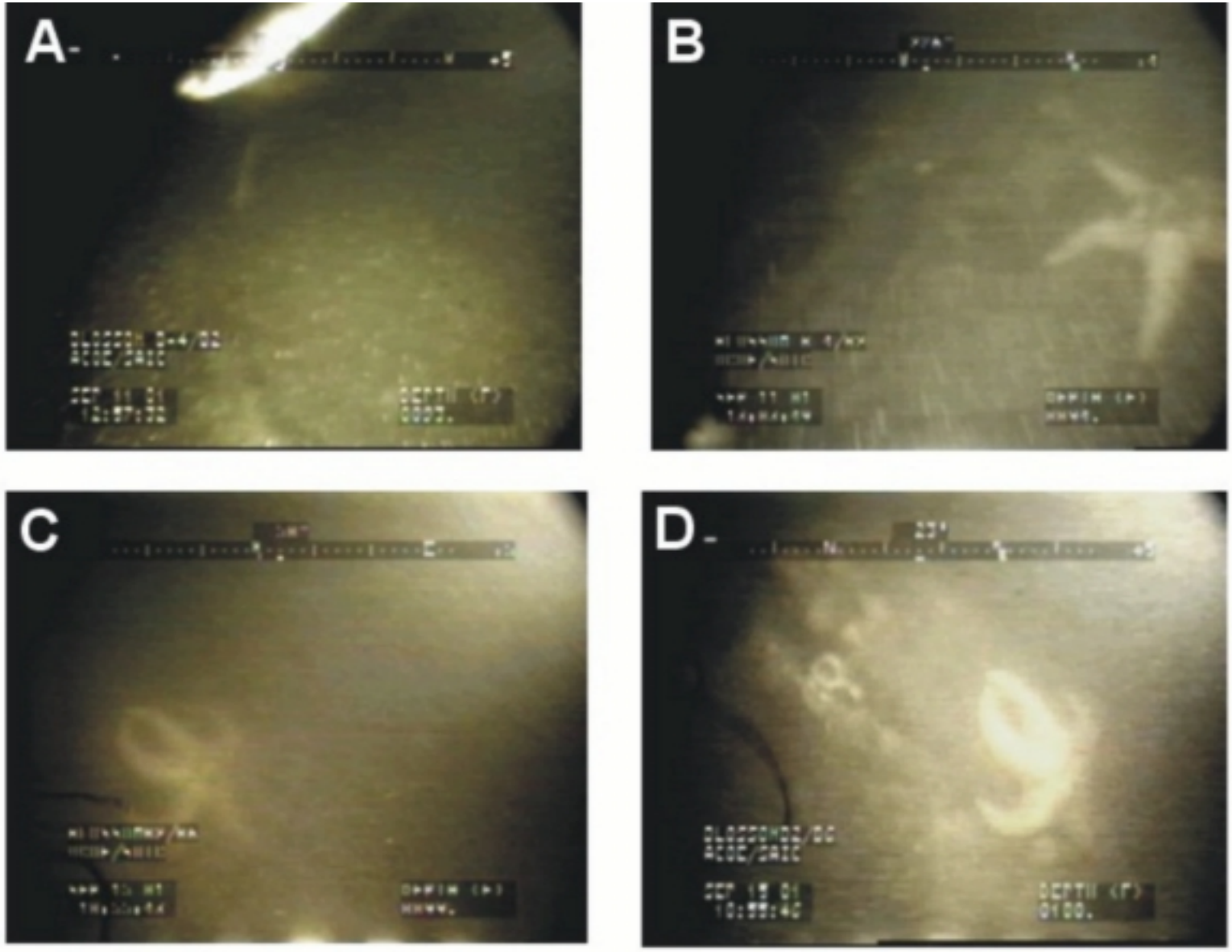
Photographic Examples from ROV Survey of Shag Rock, September 2001. Marine biological organisms include E) Bat star and turf (fix 23, 51 ft); F) Seastars: bat star and Ochre seastar (fix 27, 65 ft); G) Yellowtail rockfish, jewel anemones, and turf (fix 25, 68 ft); and H) Anemone - *Urticina* and turf (fix 27, 66 ft).



Photographic Examples from ROV Survey of Arch Rock, September 2001. Marine biological organisms include A) Bat star and turf (fix 15, 44 ft); B) Bat star and turf (fix 15, 44 ft); C) Rock greenling, bat star, and turf (fix 16, 47 ft); and D) Bat star and turf (fix 13, 41 ft).



Photographic Examples from ROV Survey of Arch Rock, September 2001. Marine biological organisms include E) Bat star and turf (fix 17, 45 ft); F) Ochre seastar, bat star, and turf (fix 14, 44 ft); G) Bat star and turf (fix 14, 44 ft); and H) Ochre seastar, bat star, and turf (fix 16, 47 ft).



Photographic Examples from ROV Survey of Blossom Rock, September 2001. Marine biological organisms include A) Unidentified pelagic fish over soft bottom (fix 1, 93 ft); B) Short-spined seastar and turf (fix 3, 91 ft); C) Short-spined seastar and turf (fix 26, 99 ft); and D) Short-spined seastar and turf (fix 26, 100 ft).