ACANTHASTER (ECHINODERMATA, ASTEROIDEA) IN THE GULF OF CALIFORNIA

ERIC G. BARHAM,[1] ROBERT W. GOWDY,[2] AND FAY H. WOLFSON[2]

ABSTRACT

Possible invasion of the coral-rich Caribbean by eastern Pacific populations of *Acanthaster*, which might follow on construction of a sea-level Central American canal, directed our attention to *Acanthaster* in the Gulf of California. Based on the literature, field notes, and a study of tagged specimens, the distribution, density, and behavior of this little known asteroid are discussed.

The population extends through some 300 miles of the southern half of the Gulf, mainly along the western shore, and appears to be geographically isolated from eastern Pacific *Acanthaster* populations known at lower latitudes. It is sparse and, even where common, average density estimates are of the order of 1/200 m^2. Through the northern part of its range, the sea star feeds primarily on small encrusting growths of *Porites californica*, but in the most southerly regions, *Pocillopora* is a frequent prey. The change in prey preference appears to be related to the distribution of the coral species and to changes in their dominant growth forms.

During a 48-h study of nine tagged specimens, 70% of the observed activity involved feeding, 20% resting, and 10% traveling. There was no clear-cut diurnal behavior, and no tendency to aggregate or to migrate as a population.

Measurements and behavioral traits indicate that *Acanthaster ellisii* is a valid binomen for the Gulf of California. We conclude that, if there is ground for concern over transoceanic invasion, it should shift to the more southerly population.

The alarm which followed early reports (Barnes, 1966; Endean, 1969; Chesher, 1969) of the devastation of South Pacific coral reefs by the crown-of-thorns sea star, *Acanthaster planci*, appears to have subsided, although interpretation of the phenomenon is still being debated (Dana, 1970; Newman, 1970; Vine, 1970; Weber and Woodhead, 1970; Dana, Newman, and Fager, 1972). However, the events have served to highlight our ignorance of the eastern tropical Pacific representatives of the genus. Furthermore, the possible construction of a Central American sea-level canal through which eastern Pacific *Acanthaster* might gain access to the coral-rich, but *Acanthaster*-free tropical Atlantic, has raised the question of the predation-potential of the American population (Newman and Dana, in press; David Pawson, pers. comm.).

The long-standing questions surrounding the taxonomic status of *Acanthaster* in the Gulf of California and adjacent regions have been further confused by the discovery of large numbers in the Secas and Contreras Islands adjacent to the Gulf of Panama (Glynn, 1970a, b; 1972), and it is not at present clear whether any or all of the American *Acanthaster* are assignable to *A. ellisii* (Gray, 1840), to *A. ellisii pseudoplanci* Caso, 1962, or to *A. planci* (L., 1758). However, we consider *A. ellisii* a valid binomen for the populations we have observed in the Gulf of California, and shall adhere to it for purposes of this report.

As recently as 1955, *A. ellisii* was known from less than a dozen lots, mostly of single

[1] Marine Environment Division, U.S. Naval Undersea Research and Development Center, San Diego, Calif.; present address: Southwest Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92037.

[2] Marine Environment Division, U.S. Naval Undersea Research and Development Center, San Diego, CA 92152.

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TABLE 1.—Numbers, distribution, and feeding behavior of *Acanthaster ellisii* in the Gulf of California.

Location	Reference[1]	Stations	Date	Number of specimens	Observation		
					Not feeding	Feeding	Prey
B. San Carlos	1	S side, Pta. Dobles	Jan. 1966	1	No data		
Pta. Sta. Inez	1	SW side	Nov. 1966	Few	No data		
Pta. Sta. Inez	1	SW side	July 1967	Few	No data		
Pta. Sta. Inez	1	SW side	Nov. 1968	Few	No data		
Pta. Concepción	1	1 mile S of B. Concepción	Nov. 1966	Few	No data		
Pta. Concepción	1	1 mile S of B. Concepción	Nov. 1968	Few	No data		
Pta. Concepción	1	1 mile S of B. Concepción	Nov. 1970	2	0	2	*Porites*
Pto. Escondido	1	SW side, Coyote Pt.	Nov. 1966	Few	No data		
Pto. Escondido	1	SW side, Coyote Pt.	Nov. 1968	Few	No data		
Pto. Escondido	1	SW side, Coyote Pt.	Nov. 1970	5	0	5	*Porites*
I. San Ignacio	1	SE side	Mar. 1971	1	0	1	*Porites*
I. San José	2	Stn. 6, SW end	Apr. 1970	5	3	2	*Pacifigorgia* (1); *Padina* (1)
I. San José	3	Stn. 6, SW end	Oct. 1971	3	No data		
I. San Francisco	4	Stn. 4, cove on S side	Apr. 1970	12	6	6	*Porites*
I. San Francisco	3	Stn. 4, cove on S side	Oct. 1971	12	7	5	*Porites*
I. San Francisco	4	Stn. 3, SW anchorage	Apr. 1970	7	No data		
I. San Francisco	2	Stn. 1-5, S side	Apr. 1970	48	Incomplete, but:		*Porites* (30); *Pacifigorgia* (1)
I. Partida	1	Pink Cliff station	Nov. 1970	4	[2]4	[2]12	*Porites*
I. Partida	1	Pink Cliff station	Mar. 1971	9	[2]18	[2]38	*Porites* (30); *Pocillopora* (2); coralline algae (2); ? (4)
I. Partida	4	Stn. 1, SW end	Apr. 1970	1	No data		
I. Partida	3	Stn. 2	Apr. 1970	1	No data		
I. Partida	3	Stn. 2	Apr. 1972	2	2		
I. Partida[3]	2	Stn. 7, 8 SW end	Apr. 1970	16	0	16	*Porites* (14); *Psammacora* (1); *Pocillopora* (1—presumed)
I. Espíritu Santo	2	Stn. 10, in B. San Gabriel	Apr. 1970	1	0	1	*Pocillopora* (1—presumed)
I. Espíritu Santo	3	Stn. 7, N. side San Gabriel	Oct. 1971	4	0	4	*Pocillopora*
I. Espíritu Santo	3	Stn. 7, N. side San Gabriel	Apr. 1972	2	1	1	*Pocillopora*
Ens. de los Muertos	3	Stn. 8, NW side P. Arena	Apr. 1972	9	4	5	*Pocillopora* (4); *Porites* (1)
Cabo Pulmo	3	Stn. 9, seaward of inner reefs	Apr. 1972	3	2	1	*Porites*
B. Frailes	3	Stn. 10, NE side	Apr. 1972	1	0	1	*Pocillopora*

[1] 1 = Authors.
2 = Dana and Wolfson (1970).
3 = Faulkner, unpublished notes.
4 = Faulkner, cited in Dana and Wolfson (1970).
[2] Based on multiple observations of same specimens (See text and Table 3).
[3] Cited as Espíritu Santo.

specimens (Madsen, 1955). The fact that the sea star inhabits rocky subtidal substrates has made it generally unavailable to shore collectors and impossible to dredge; only with the increased use of diving techniques has it become accessible. Accordingly, the literature is sparse.

Since Madsen's review (1955), *A. ellisii* has been described and contrasted to *A. ellisii pseudoplanci* by Caso (1962), and Barham and Davies (1968) and Glynn (1972) have mentioned it. Only Dana and Wolfson (1970) have dealt with any aspects of its biology. It is apparent from recent field observations (Dana and Wolfson, 1970; D. J. Faulkner, pers. comm.; and the material to be presented here) that the scanty records reflect our poor knowledge of the invertebrate fauna of the Gulf of California, rather than the prevalence of the sea star. This paper aims at adding to our understanding of the habits and habitats of *Acanthaster* in the Gulf of California.

We present information based on three distinct types of observations: 1) Presence and absence of *A. ellisii* noted in the course of our ecological surveys in the Gulf of California between 1965 and 1968, prior to a defined interest in the species; 2) numbers of *A. ellisii* and its prey observed by us at various locations during specifically directed surveys in November 1970 and by D. J. Faulkner in 1970, 1971, and 1972; 3) studies of tagged specimens at "Pink Cliff" station, Isla Partida, in November 1970 and March 1971.

Distribution of *Acanthaster* in the Gulf of California

The early records contribute little information on distribution. According to Madsen (1955), the collection site of Gray's type specimen was simply given as South America, and the two specimens described under the name of *ellisii* by Perrier were of unknown origin. Verrill (1869) listed La Paz as the locality for his *A. ellisii*, but the reference may be to the port from which it was shipped (Squires, 1959), and it was probably collected elsewhere. Thus, prior to 1970, the only valid records for *Acanthaster* in the Gulf of California are for Puerto Escondido, where Steinbeck and Ricketts (1941) collected several specimens, and where Madsen's (1955) type specimen was taken by an Allan Hancock Expedition. Some of Caso's specimens were also collected there by an Allan Hancock Expedition in 1940 (Caso, 1962).

Table 1, showing the distribution patterns of *A. ellisii* in the Gulf of California, combines our notes, the data given by Dana and Wolfson (1970), and the information contributed by Faulkner (cited in Dana and Wolfson, 1970). The known range of the species, extending through some 300 miles along the western shore of the Gulf of California, is shown in Figure 1.

No *Acanthaster* have been reported on the eastern shores of the Gulf, and our extensive search of the three areas which appear to offer suitable environments produced only two specimens: one at Bahía San Carlos, north of Guaymas, in January 1966 (we found none there in November 1968 and November 1970); the other, after a lengthy search, at Farallon San Ignacio. This small rocky islet offshore from Topolobampo represents one of the few likely environments for the asteroid for hundreds of miles along that part of the coast. No specimens were observed at the southeast end of I. Tiburon or on the adjacent mainland at Pta. Sargento.

Within its known range, *A. ellisii* is most often found on the south sides of islands and points, or in small embayments in the lee of northerly winds and partially protected from the south (Table 1). Note from Table 2, however, that although present at adjoining locations, it is not found in the more thoroughly protected bays and coves, such as Bahía Coyote, Pichilinque, and the inner bay at Puerto Escondido. Apparently the asteroid prefers habitats with some degree of wave action, but protected from violent wave shock and strong surge.

With two exceptions, there appears to be a good degree of correspondence in the distributions of *A. ellisii* and corals. The first exception is Bahía San Gabriel, where heavy growths of *Pocillopora* and other corals occur in a reeflike formation, and where Dana and Wolfson (1970) found only one *A. ellisii* in a thorough search of some 1,500 m². The second is El Pulmo, where by far the most extensive stands of branching

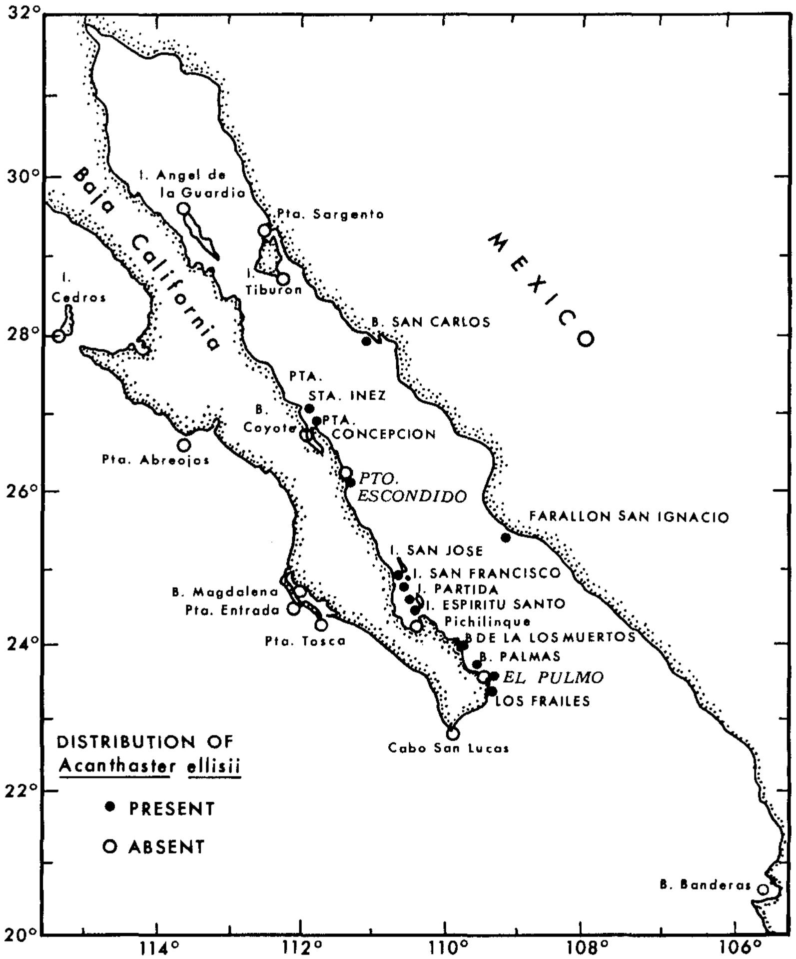

FIGURE 1.—Distribution of *Acanthaster ellisii*.

stony corals in the Gulf occur. We found no *Acanthaster* there on two visits, although we dove over large areas of the two shallower reefs and were towed behind a skiff over extensive regions of the deeper reefs. Sport divers have reported *A. ellisii* there, but the species is not easily identifiable on casual observation, and confusion with other asteroids, particularly with the similarly sized, heavy-spined, and abundant *Nidorellia armata,* is common. Faulkner's report (pers. comm.) of two specimens taken in relatively deep water outside the main reefs at El Pulmo represents an anomaly in the distribution of *A. ellisii* as otherwise observed.

Density

Except at the islands near La Paz (Islas San José, San Francisco, Partida, and Espiritu Santo, to which we shall refer as the "island complex") low densities of *A. ellisii* are suggested by the numbers in Table 1. Dana and Wolfson (1970) give 0.0045/m^2 (1/222 m^2) for those islands, and the nine specimens we found in the thoroughly searched area of approximately 2,000 m^2 at "Pink Cliff" station on Isla Partida translate to an identical average. The high density at Pto. Escondido, 0.005/m^2 (1/200 m^2), is deceptive, as we searched a preselected area where the sea stars were con-

TABLE 2.—Locations in the Gulf of California and adjacent areas where *Acanthaster ellisii* was not observed.

Location	Station	Date	Man hours underwater observation
Gulf of California			
I. Ángel de la Guardia	S. side of Arch Rock in P. Refugio	July 1967	8
I. Ángel de la Guardia	S. side of Arch Rock in P. Refugio	Nov. 1970	4
Pta. Sargento	SW side	July 1967	4
I. Tiburon	SE end	July 1967	4
B. San Carlos	S. side Pta. Dobles	Nov. 1968-Nov. 1970	16
B. Coyote	4 stations on or near I. Blanca	Nov. 1966	60
B. Coyote	4 stations on or near I. Blanca	July 1967	4
B. Escondido	Inner bay, S and E sides	Nov. 1966-Nov. 1968 Nov. 1970	8
P. Pichilinque	Bay on S. shore	Nov. 1966, Jan. 1968, Nov. 1968, Nov. 1970	50
B. Los Palmos	NW Shore	Jan. 1968	4
C. Pulmo	Lagoon and inner reef	Jan. 1968	6
C. Pulmo	Lagoon, inner and outer reefs	Mar. 1971	12
C. San Lucas	Sheppard's Rock area	Jan. 1965, Jan. 1968	20
West coast Baja California			
I. Cedros	SW end	Jan. 1965	8
Pta. Abreojos	SW end	Jan. 1965	2
B. Magdalena	NE shore	Jan. 1965	2
Pta. Entrada	Inside passage	Jan. 1965	8
Pta. Tosca	SW end	Jan. 1965	8
West coast Mexico			
Banderas Bay	5 stations E and S regions	Nov. 1968	40
Banderas Bay	1 station E region	Mar. 1971	4

centrated. The nine specimens reported by Faulkner (pers. comm.) at Ensenada de los Muertos constitute the only sizeable population known to the south of the La Paz island complex, but density figures are not available.

"PINK CLIFF" STUDY

Observations at Pink Cliff station provide an insight into the behavior of *A. ellisii*. We made preliminary observations there on four specimens in November 1970; a further study was conducted over a 48-h period in March 1971.

Study Area

The Pink Cliff study area covers about 2,000 m^2 in the northeast corner of El Cardonal Bay on the west side of Isla Partida (lat. 24°32′10″ N; long 110°23′30″W). The pink-pumice cliff extends about 3 m underwater and then curves into a wave-cut platform which interfaces at about 10 m with the sand bottom. Several large monument-like rocks with truncated tops stand isolated from the cliff. A few reeflike ledges lie farther seaward, and an extensive pile of large boulders is located near the northern edge of the platform. (Figure 2, based on underwater sketches and substrate measurements, gives a schematic picture of the area.)

Coralline algae predominate on rock and cliff faces. A rich growth of sessile organisms, dominated by sponges, tunicates, hydroids, and gorgonians, is concentrated on and near the vertical cliff and monument rocks. The upper rock surfaces and much of the platform are covered with a thin veneer of filamentous algal material. At the deepest levels, on the inshore sides of the rock pile, there is a luxuriant stand of the brown alga, *Padina*.

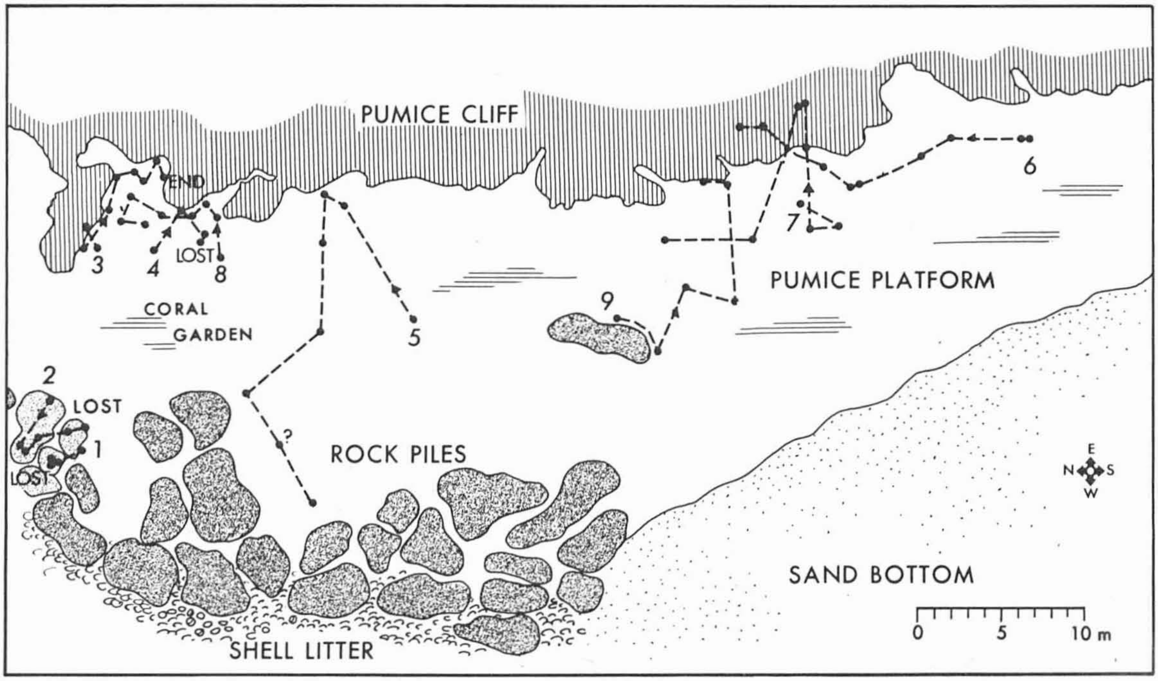

FIGURE 2.—Schematic diagram of Pink Cliff study area, Isla Partida, showing the relative positions and movements of the nine tagged *Acanthaster ellisii* during the 48-h study period. Depth of water at the interface between hard and soft bottoms is about 10 m.

Daytime underwater visibility in 1970 was about 20 m; in 1971, it varied between 6 and 15 m. Night visibility was reduced by swarms of mysids, polychaetes, and larval fishes which concentrated in the beams of our hand-held lights. Water temperatures were 27°C during the fall visit, 18°-21°C in the spring.

The Coral Fauna

Pocillopora is the conspicuous coral, although there are less than 20 large heads; the majority stand as scattered individuals in the "coral garden" near the cliff base in the northeast part of the platform. Several are inhabited by hawkfish (see Figure 3) and anomuran crabs. A few small *Pocillopora* grow on the lower vertical surfaces of the cliffs and monument rocks. Scattered small colonies of the dendrophyllid coral, *Tubastrea aurea*, are restricted to the deeply shaded sides of the monument rocks and cliff walls.

The large number of small encrusting *Porites californica* contradicts the first impression of a sparse coral fauna. In the deeper regions, these scablike coralla (see Figure 4) are about 4-5 cm in diameter and well separated from one another; with increasing height, they become progressively larger and less regular in outline, encrusting the pits and crevices, or covering small protuberances to form knobs.

The abundant *Porites* on the cliff face is so highly irregular in outline that it was impossible to distinguish individual colonies, but we attempted to count the coralla within a 0.5 m-diameter ring placed in five locations on each of two transects along the platform. Numbers increased from 50 coralla/m^2 on the seaward edge of the platform to 100 coralla/m^2 at the cliff base. In the surge shadow cast by a 3 m-high rock, and on the adjacent region of the platform which is protected from surge by the reef, there were as few as 10 coralla/m^2.

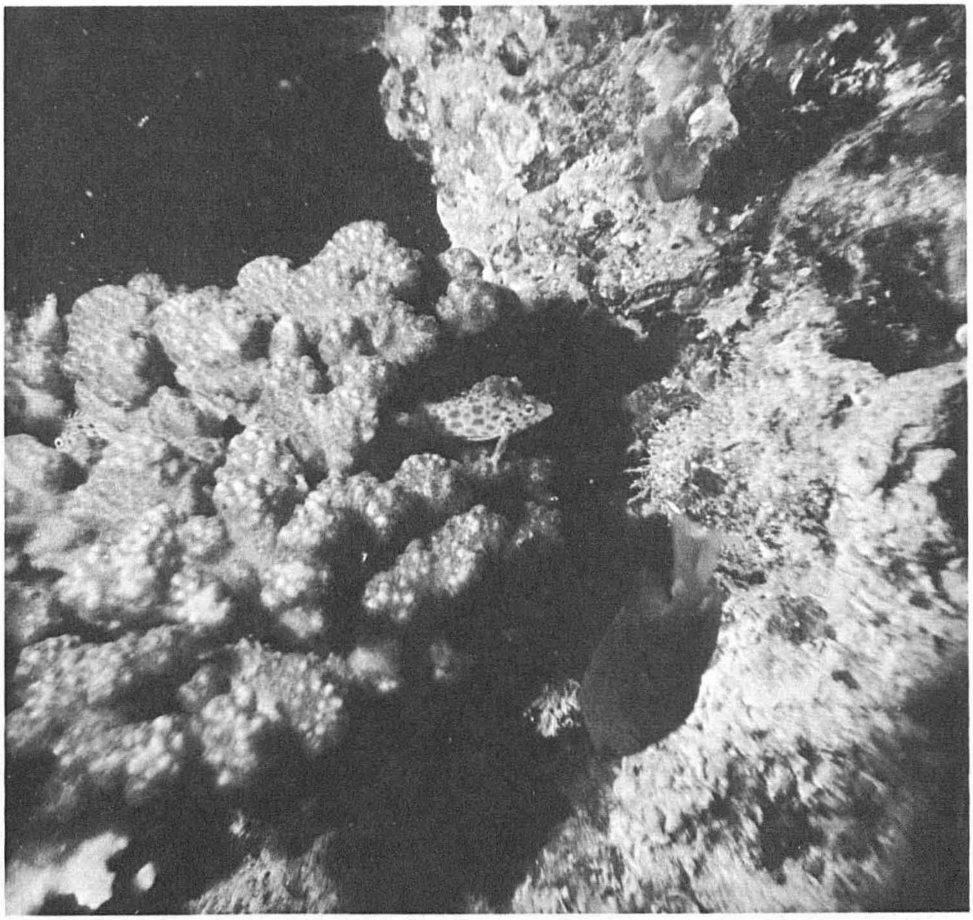

FIGURE 3.—An isolated head of *Pocillopora* sp. harboring two hawkfish (family Cirrhitidae), photographed near the base of a monument rock in the Pink Cliff study area. Only minor blemishes are evident on the distal regions of the branches.

Methods and Procedures

On 1 November 1970, we tagged four *Acanthaster ellisii* in situ by threading monofilament, to which numbered tapes were knotted, through the body wall and under the dermal ossicles with a curved upholstery needle. The operation was particularly awkward because of the necessity of wearing heavy gloves and entailed considerable manipulation of the animals, causing one specimen to react in an abnormal manner. The 16 observations made in this preliminary study are summarized in Table 1.

For the 1971 survey, the nine specimens located within the search area were tagged by simply tying numbered tapes to a ray (Figure 5). (This procedure also required great care and has additional drawbacks. If the monofilament is tied too tightly, the sea star may autotomize the insulated arm, as one of our specimens did after 40 h. Conversely, two loosely tied tags snagged and pulled free. Fortunately, they were found near animals whose characteristics corresponded to originally tagged individuals, and the tags were retied.)

The position of each specimen was marked with a short length (approximately 30 cm) of

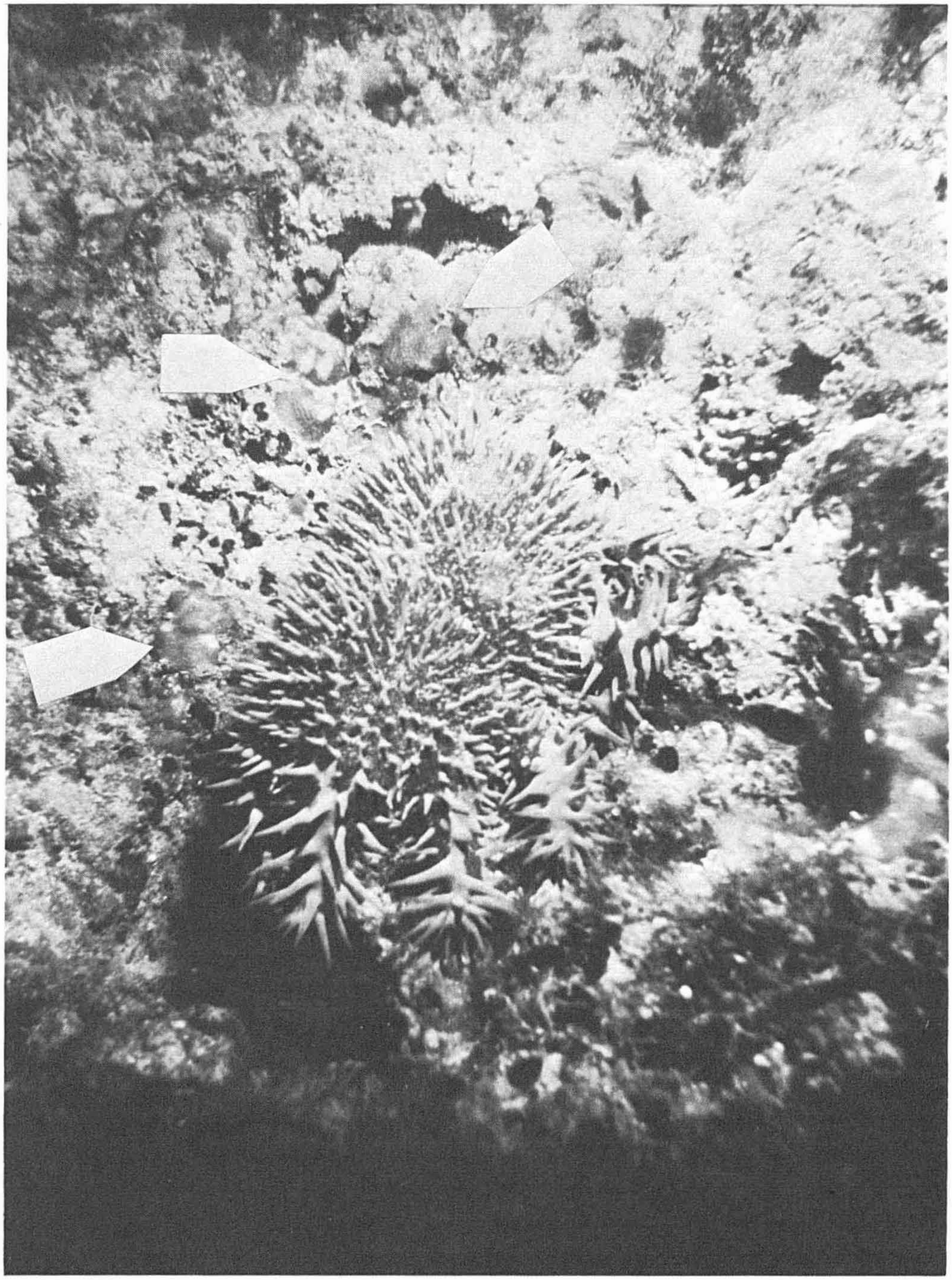

FIGURE 4.—A. *Acanthaster ellisii* in feeding posture on the cliff wall at the Pink Cliff study area. Several of the numerous small *Porites californica* encrustations are indicated by the arrows. The two small coralla in the upper left show damage more characteristic of fishes than of *Acanthaster*. B. The same specimen pulled back to expose the *Porites* nodule (indicated by the arrow) on which it was feeding.

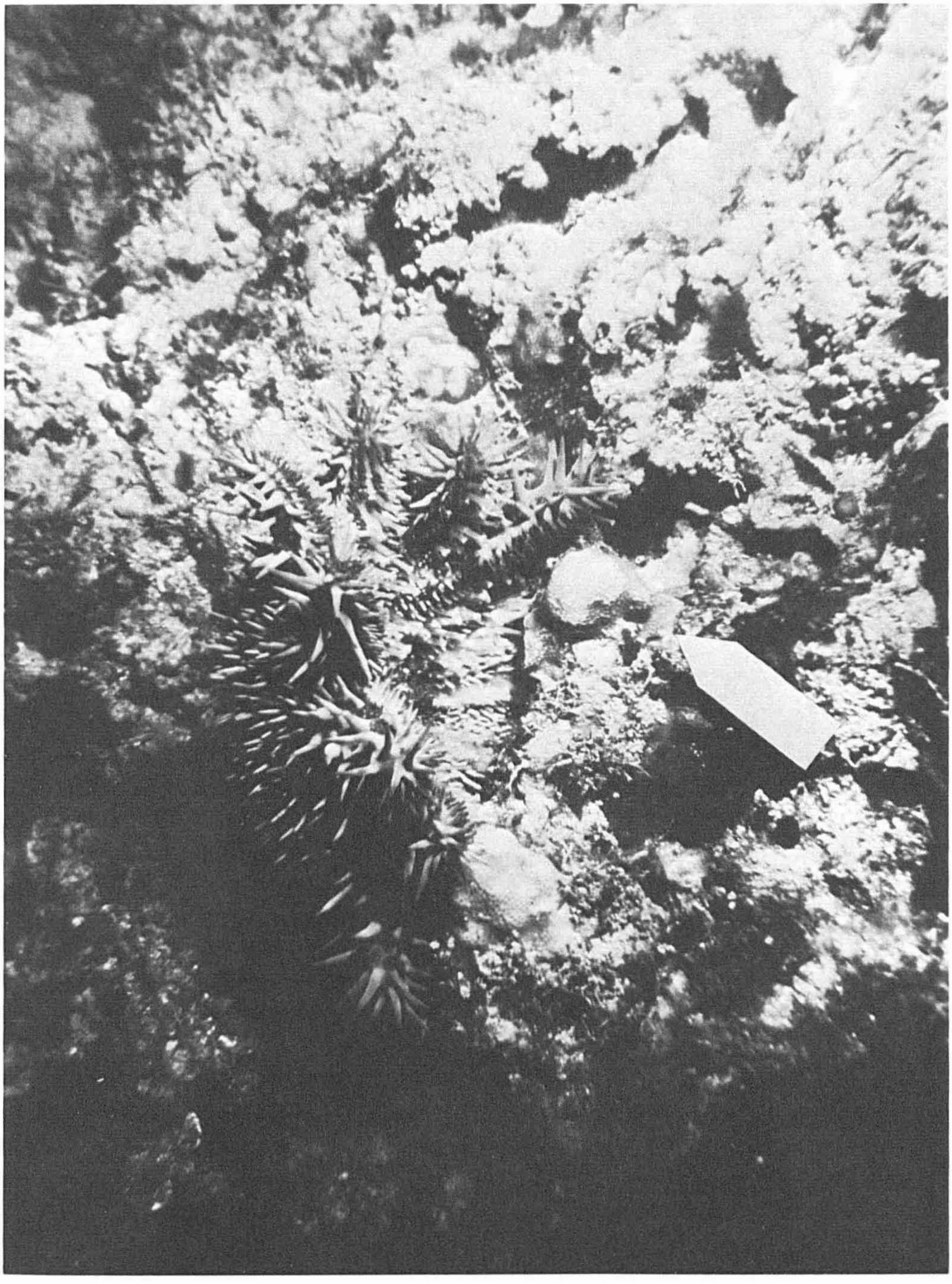

TABLE 3.—Tagging experiment, Pink Cliff station, Isla Partida, March 1971. Behavior, prey, and distances moved between observations.[1]

		27 March 1971								28 March 1971						29 March 1971		Total	
Specimen	0830-1130 Original location	Move (m)	*1* 1415-1515	Move (m)	*2* 1615-1645	Move (m)	*3* 1930-2030	Move (m)	*4* 0920-1015	Move (m)	*5* 1115-1145	Move (m)	*6* 1430-1510	Move (m)	*7* 2030-2130	Move (m)	*8* 0915-1000	Time (h)	Dist. (m)
1	Rock pile	0.6	F/?	0	F/P	0	F/P	—	—	—	—	—	—	—	—	—	—	12	0.6
2	Rock pile	3.7	F/P	0	F/P	0.5	R	1.3	F/P	0	F/P	0.7	T	—	—	—	—	29	6.2
3	Coral gardens	1.4	F/P	0.2	F/P	2.2	R	2.2	F/P	1.7	F/A	0.5	R	0.8	R	3.0	F/P	48	12.0
4	Coral gardens	3.6	F/P	2.6	F/P	0	F/P	—	—	—	—	—	—	—	—	—	—	12	6.2
5	Platform	6.6	F/P	0.5	F/?	1.9	F/P	2.9	F/P	4.5	T	(/)	(/)	6.0	R	2.2	R	48	24.0
6	Platform	0	F/PP	4.9	R	1.8	R	4.2	F/PP	0	F/PP	1.7	T	6.0	R	6.0	T	48	24.6
7	Cliff base	1.9	R	1.3	T	4.2	F/?	2.7	F/P	0	F/P	7.0	F/P	2.0	F/P	3.0	F/P	48	22.1
8	Coral gardens	2.5	F/Pc	1.0	F/P	(/)	(/)	1.0	T	2.2	R	2.4	R	1.3	F/PA	1.3	F/Pc	48	11.7
9	Reef rock	([2])			F/P	2.0	F/?	3.0	F/P	0	F/P	4.6	F/A	(/)	(/)	6.0	F/P	42	15.6
																		330	123.0

[1] F = feeding
? = undetermined
P = *Porites*
— = lost
R = resting
T = traveling
A = coralline algae
(/) = missed
Pc = *Pocillopora*

[2] Not tagged until Period 2.

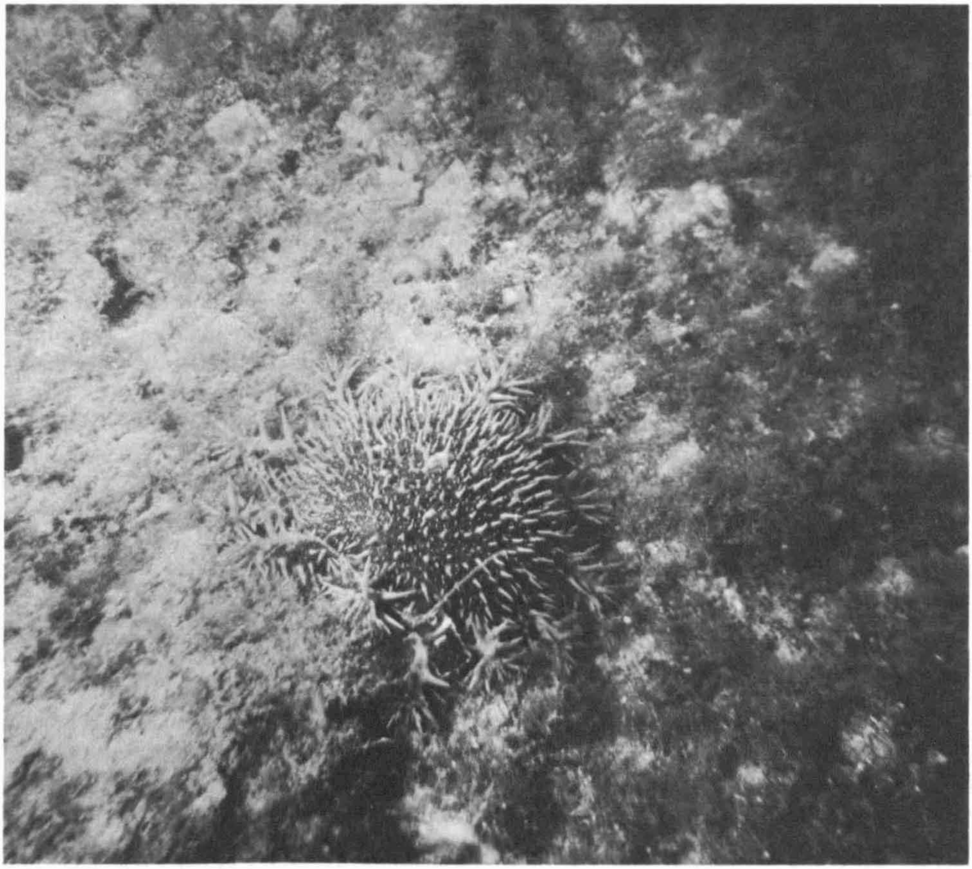

FIGURE 5.—*Acanthaster ellisii*, specimen no. 1, photographed while moving over a large rock in the Pink Cliff study area. The tag is tied to the proximal part of the arm nearest the camera.

plastic PVC (polyvinyl chloride) pipe weighted with lead strips to stand vertically. Small surface buoys equipped with life-jacket lights were anchored near each location to aid in night operations.

Observation and search periods are given in Table 3. Time on the bottom was dependent on our scuba air supply. The greatest care was taken to minimize disturbance of the animals. Specimens on the move were not touched and, to prevent interruption of their activity by stimulating the "shadow reflex" (Hyman, 1955), we tried to avoid swimming over them. The activity of animals at rest was investigated by gently lifting a part of the body with a knife blade. Distance of movement was measured with a meter stick; direction was determined by compass bearings. Following each observation, the pipes and buoy anchors were transferred to the new position.

Specimens in the open were recovered with relative ease; locating them on the rock pile or in its interstices was difficult or even impossible, especially at night. During the course of the study, we failed to recover individuals on six occasions. Three times the "lost" specimen was found on the succeeding search; we suspect that no. 1 and 2 specimens, which were last seen close to their original position (see Figure 2), had moved out of the search area.

Behavior

Table 3 summarizes the 56 observations made during the 48 h of the Pink Cliff study. In 38 instances (68%), the specimen was feeding, that is, it was immobile, hunched or puffed up (Figure 4a), with stomach everted and covering the prey. Feeding was observed in 31 of the 43 daytime observations (72%) and 7 of the 13 night observations (54%). On 12 occasions, 6 at night and 6 during the day, the asteroids were "resting," i.e., they were immobile and the stomach was within the gastric cavity. Six times the observed specimen was "traveling," moving over the substrate on tube feet, one slightly lifted arm leading (Figure 5). Traveling was only observed during the day, but the evidence is insufficient for postulating a diurnal rhythm.

Feeding

Analysis of the 38 feeding observations indicates a definite prey preference. *Porites* comprised 79% of the food (29 observations, plus one of simultaneous feeding on *Porites* and coralline algae). *Pocillopora* was fed on two times (5%) and coralline algae two times (5%). On four occasions (11%) it was impossible to determine the prey.

Specimen no. 8, which fed simultaneously on coral and alga, was also the sole predator on *Pocillopora*. Unusual behavior was also exhibited by no. 6 which, on three occasions, displayed the singular habit of feeding on two or three *Porites* colonies at once.

Movement

The sequence of behaviors observed suggests a general pattern of movement. The individual remains for one or more hours over a small *Porites* encrustation, and then moves off, usually to another corallum which may be several meters distant. A series of feeding stops is followed by a resting period, which may also last for several hours, or by several rest stops interspersed with short moves. It should be noted that, even though specimen no. 3, 5, 6, and 8 were at rest in consecutive observations separated by intervals of 3-13 h, in each case the individual had moved between the observation periods.

The specimen which reacted abnormally to the 1970 tagging operation provides some evidence for the rate at which *A. ellisii* is capable of moving: when returned to the substrate, it immediately embarked on a continuous journey, covering a distance of approximately 10 m in a little over an hour. More refined observations are necessary for estimation of rate of movement, but a rough idea can perhaps be gained from the Pink Cliff study. Dividing the total elapsed time between midpoints of the first and last observation periods (33 h) by the summed distances moved (123 m) gives an average ground coverage of 0.373 m/h. A higher figure is derived from considering the two cases (between period 2-3 and 5-6) in which the intervening intervals were approximately equal (about 3½ h). Distances covered between those periods ranged from 0 to 7.0 m and averaged 2.1 m, giving a rate of 0.6 m/h. Furthermore, average rate in the rock pile and coral gardens, where coral are most abundant, was 0.246 m/h, approximately half of that on the relatively coral-poor platform (0.464 m/h), suggesting correlation with density of the corals.

ACANTHASTER ELLISII AS PREDATOR

Crucial to an evaluation of *A. ellisii* as a potentially destructive coral predator is its foraging behavior throughout its range. North of the island complex, small crustose colonies of *Porites* are the only positively identified prey of *A. ellisii*. In the island complex, which falls in the middle of its known range, *Porites* apparently remains the major food item, with gorgonians, algae, and *Pocillopora* attaining minor importance. (It might be mentioned here that feeding by *A. ellisii* on *Pocillopora* was inferred, rather than actually observed, by Dana and Wolfson (1970).) The few observations which have been made farther to the south suggest that *Pocillopora* is more frequently fed on than *Porites*.

This apparent shift in prey preference may reflect the distribution of corals in the Gulf of California. From an ecological standpoint, the ranges for coral genera given in the most recent treatment of the subject (Squires, 1959) can be misleading. For example, Squires shows the northern limit for extant *Pocillopora* species as a line extending across the Gulf from about the level of Santa Rosalía to Guaymas. The line is based on a single specimen of *Pocillopora robusta* (= *elegans*) collected by an Allan Hancock Expedition at Isla San Marcos (Durham and Barnard, 1952). John Garth of the Hancock Foundation informs us that the specimen was dredged in 20 fathoms south of Isla San Marcos (lat. 27°09′05″N; long. 112°04′25″W) and appears to have been taken alive. In our experience, the only common coral north of the island complex is *Porites*, and this Isla San Marcos specimen must represent an isolated outpost of *Pocillopora*. Squires' Table 1, summarizing the diminution of the hermatypic coral fauna in the northern regions of the Gulf, gives a more accurate picture of the situation as we have seen it. It seems obvious, then, that if *A. ellisii* is primarily an obligate coral feeder, its major prey through the northern part of its range must be *Porites*.

The varying growth forms of the corals may also enter into the prey preference of *A. ellisii*. In gross morphology, *Porites* is highly plastic, showing phenotypic gradation from encrusting colonies in the northern part of its range to columnar, branched, or nodular forms in the south. However, the influence of latitude is cancelled in protected situations in the lower mid-Gulf, such as Bahía Coyote and the inner bay at Puerto Escondido, and *Porites* tends to assume the dome-shaped heads and large nodular form typical of the southern type. We have never seen *A. ellisii* in these quiet-water environments.

It is noteworthy that we have never seen *A. ellisii* on large or ramose corals at any locality. The *Porites* being preyed on in all of our observations were so small that the sea stars appeared to be sitting on a coral-free substrate; only when the animal was lifted could the coral be seen and identified. Furthermore, our observations of predation on *Pocillopora* all involved feeding at substrate level. In a crude field trial, a traveling specimen immediately began to feed on a broken branch that we had placed in its path; and the three observations at Pink Cliff station (all by specimen no. 8) involved one instance of feeding on the underside of a low branch and two on broken branches. However, at the end of the study, no. 8 fed on a ramose *Pocillopora* when dropped directly on top of it, and Faulkner (pers. comm.) reports that south of La Paz, where *Pocillopora* assumes a densely packed, reeflike formation, *A. ellisii* feeds on top of the colonies. It thus appears that some factor or factors may prevent the asteroid from mounting upright, solitary corals.

Weber and Woodhead (1970) reported that fish and crabs living among the branches of *Stylopora*, a close relative of *Pocillopora*, defend that coral from attack by *A. planci*. *Pocillopora's* symbionts (Figure 3) perhaps serve a similar function.

The experimental work of Barnes, Brauer, and Jordan (1970) and Brauer, Jordan, and Barnes (1970) may explain the marked preference of *A. ellisii* for discrete, low coralla. Working with *A. planci*, these investigators demonstrated that, while the tube feet are sensitive to nematocysts, the stomachs respond positively to nematocyst-containing tissue. From these experiments, and from the observation that the sea star uses its arms and spines as much as possible when climbing coral heads, they infer that the humped feeding position of *A. planci* may serve to keep the tube feet free of the prey's stinging polyps. If *A. ellisii* responds to nematocysts in the same ways, small, isolated, crustose coralla that can be easily straddled and then covered by the stomach would constitute more acceptable prey and would be selected over larger growths.

Examination of small *Porites* fed upon by *A. ellisii* suggests that the entire colony is not necessarily destroyed; white patches, which indicate that the zooxanthellae have been digested, are left mainly on regions that protrude above the general level of the substrate. We consistently observed, however, that the entire corallum appears to be covered with a mucous film, and suggest that the extent of the damage inflicted on small *Porites* by *A. ellisii* bears further investigation.

It should be borne in mind that not all coral damage can be attributed to *A. ellisii*. The report of predation by *Pharia pyramidata* (Dana and Wolfson, 1970) is the first indication that the smaller asteroid, which occurs throughout the coral areas of the Gulf, is also a coral-feeder. And, of course, certain fishes are well known to be coral-browsers and commonly leave gouge marks on the coralla.

The amount of *Porites* available to *A. ellisii* in the preferred small form is difficult to evaluate. The vast numbers of small encrustations have, perhaps, been unappreciated by coral workers in the Gulf. Dana and Wolfson (1970) estimate approximately 3% coral coverage in their survey areas. While our attempt to count the numbers of *Porites* at Pink Cliff station does not warrant critical treatment, we estimated that the encrustations covered roughly 10% of the substrate.

The important question of how much coral is necessary to maintain the *A. ellisii* population in the Gulf of California must await some definitive information on coral growth rates in that physical regime. Dana and Wolfson (1970) calculated that an average-sized specimen would consume 5.3 m^2 of coral per year. Our rough estimate of 10% coral coverage at Pink Cliff station would provide 20 m^2 of *Porites* per individual. If that can be extrapolated to the Gulf as a whole, even with an allowance for competition, it would appear that *A. ellisii* is living well within the available resources of its environment.

Miscellaneous Observations

In its natural environment, *A. ellisii* reacts to a touch or a cast shadow with a rapid retraction of the dermal papulae, resulting in an overall color change from dark red (or orange or yellow) to dull gray. If not further disturbed, the papulae are soon extruded, restoring the original color; if removed from the water, however, the gray persists. This habit reconciles the conflicting descriptions of the species as gray (Steinbeck and Ricketts, 1941) and as rufous (Ziesenhenne, 1937). Madsen (1955) mentions the same phenomenon for *A. planci*.

When feeding or at rest, the aboral spines are partly hidden in the papulae, and *A. ellisii* presents a deceptively harmless appearance. Although it can be more easily removed from the substrate than most asteroids, it should be handled with caution. Ziesenhenne (1937) was uncertain of the toxicity of the spines, but two of us (Barham and Wolfson) can attest to the painful and long-lasting effects of a puncture.

To augment the meager morphological data available for *A. ellisii*, we collected and measured six specimens at the termination of the 1971 study. Number of arms varied from 12 to 15, madreporic bodies from 5 to 9. Overall diameters ranged from 10.7 to 15.4 cm, disk diameters from 7.6 to 9.1 cm. Ratios of disk diameter to arm length (calculated from overall diameter minus disk diameter) ranged from 1.3 to 1.6.

(In comparing specimens, it should be noted that their general appearance will differ markedly, depending on the method of preservation. Dried specimens tend to "collapse" and appear less spiny, much flatter, and more bat-armed than if either fixed in preservative before drying or maintained in the preservative. Our specimens were preserved in Formalin[3] and then dried.)

Distribution of *Acanthaster* adjacent to the Gulf of California

We have found no *Acanthaster* at Banderas Bay, our most southerly station, although the environment seems ideal for the sea star. Specimens designated as *A. ellisii* have been reported at Clarión, Roca Partida, and Socorro Islands in the Revillagigedo Group, some 24° south of the tip of Baja California (Ziesenhenne, 1937), and the subspecies, *A. ellisii pseudoplanci*, was described (Caso, 1962) from specimens collected at various locations in those islands. Whether these identifications will survive taxonomic review of the genus remains, of course, to be seen.

[3] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

It would be of considerable interest to know if *Acanthaster* is present on the Tres Marías Islands and along the great stretch between Farallon, San Ignacio, and Panamá, or if the distribution of the genus is indeed as discontinuous as it now appears.

CONCLUSION

Our adherence to the taxon, *Acanthaster ellisii*, stems from the conviction that the binomen is valid for the Gulf of California. Regardless of final decisions on the taxonomy of the more southerly, oceanic populations of *Acanthaster*, we believe that the Gulf populations constitute a distinct form.

Dana and Wolfson (1970), who have observed both *A. planci* and *A. ellisii* in the field, point out that the behavior of the two species is strikingly different. The information presented here indicates that, unlike *A. planci*, *A. ellisii* is not cryptic during daylight hours and feeds both night and day. Even where its population densities are similar to those given by Chesher (1969) for infestation levels of *A. planci*, *A. ellisii* does not appear to aggregate or to migrate as a population.

In gross morphology, *A. ellisii* also appears to be quite distinct from *A. planci*. Madsen (1955) stresses the disk-diameter to arm-length ratio as the most conspicuous difference between the American and Indo-West Pacific forms; our ratios fall well below the 1.9:2.2 ratio established for *A. planci*. (Other taxonomic characteristics appear to be too subtle and variable for comment by a nonspecialist.)

In conclusion, from the evidence presented in this paper, *A. ellisii* gives every appearance of living in harmony with its environment. There is nothing to suggest that it represents a threat to the coral fauna within its geographic range or a potential threat to any area beyond it.

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