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To: Head, Biology Branch
Office of Naval Research
Department of the Navy
Washington 25, D.C.

6 May 1953

From: Bruce W. Halstead, M.D., Project Director
School of Tropical and Preventive Medicine
College of Medical Evangelists
Loma Linda, California

Subj: REPORT ON AN INVESTIGATION OF POISONOUS AND VIOLENT FISHES AT
PALMYRA ISLAND, LINE ISLANDS, DURING 13 APRIL TO 2 MAY 1953.

INTRODUCTION

The northern Line Islands, which comprise Kingman Reef, Palmyra, Washington, Fanning and Christmas Islands, represent one of the most interesting poisonous fish areas in the tropical Pacific. Prior to 1949 fishes in the Line Islands, with the exception of puffers, were edible. Large numbers of red snapper were formerly shipped from Palmyra Island and sold in the Honolulu markets. Then in 1943 the first of a series of outbreaks were reported from eating Palmyra red snappers. During the winter of 1944 there were two different outbreaks involving thirty-eight cases of fish poisoning which occurred in Honolulu from eating sea bass that had been shipped in from Christmas and Midway Islands. Between February 1946 and April 1947 there were ninety-five cases of fish poisoning which occurred at Fanning Island from eating rockcod, pompano, surgeonfish, red snapper, parrotfish and mullet. The interesting thing about this latter outbreak was that the victims had eaten the same species of fishes which they had always eaten. Strange as this phenomenon might appear the story had been checked and rechecked on a number of different occasions and has been adequately documented as a scientific fact. Since 1947 there have been numerous outbreaks among both native and transient populations in the northern Line Islands. At the present time the reef fishes of the northern Line Islands are not permitted to be sold on a commercial basis in the Territory of Hawaii.

During the latter part of 1950 a small collection of fishes which had been collected by the Pacific Fishery Investigations, U.S. Fish and Wildlife Service, in the Line Islands were shipped to us for analysis. Some of these fishes were found to be toxic. Then during 4 January to 6 March 1951, Mr. Kenneth Groves of our staff conducted a field investigation in the Line Islands. The trip was sponsored by the Office of Naval Research and the Pacific Oceanic Fishery Investigations. The material obtained from the 1951 trip was screened and again toxic fishes were found. In reviewing this material it was felt that a larger collection of fishes should be obtained from the Line Islands and that a more thorough survey should be conducted on one of the islands which would be representative of the group. Palmyra was selected on the basis that it was an American possession and has been the center of a number of epidemics. The survey was made during the month of April since the fishes would be in the midst of their reproductive period and the toxicity in certain species would be at the maximum.

Because Palmyra is uninhabited, except for the caretaker, Mr. Otto Hornung, it was necessary for us to transport our food, collecting equipment, boat, outboard motor, gasoline and other facilities. All of these facilities were supplied through the cooperative efforts of the Armed Forces.

The scientific party consisted of Norman C. Bunker, Donald G. Ollis, Leonard S. Kuminobu, F. Douglas Horton, Robert L. Smith and Bruce W. Halstead.

Itinerary

13 Apr 53: DEPARTED LONG BEACH, CALIFORNIA, 0500.

...By car to Lockheed Air Terminal, Burbank, California. From Burbank to San Francisco via United Air Lines flight 451 at 0730. Arrived San Francisco airport 0930, where an Air Force carryall

took us to Travis Air Force Base.

14 Apr 53: DEPARTED TRAVIS AIR FORCE BASE, 1030, on flight R-265/14.

ARRIVED HICKAM FIELD 2100.

15 Apr 53: DEPARTED HONOLULU 1530, aboard Coast Guard Craft Buttonwood, enroute for Palmyra Island.

19 Apr 53: ARRIVED PALMYRA ISLAND, 1700.

20 Apr 53: Went ashore with personal luggage and some of the lighter equipment. Set up base of operations in old boat house where fresh running water and electricity were available.

21 Apr 53: Buttonwood entered lagoon, tied up at dock and deposited the rest of our equipment.

22 Apr to 29 Apr 53: General Collecting operations carried out.

30 Apr 53: DEPARTED PALMYRA ISLAND ON WATS PLANE, 1130.

ARRIVED HICKAM FIELD 1715.

1 May 53: DEPARTED HICKAM FIELD 1900 on flight 255-06.

2 May 53: ARRIVED TRAVIS AIR FORCE BASE 1015.

DEPARTED TRAVIS AIR FORCE BASE 1220 via base operations flight to Norton Air Force Base, San Bernardino, Calif. Transportation by carryall was provided to Loma Linda.

GENERAL DESCRIPTION OF PALMYRA ISLAND

Palmyra Island (05° 52' N., 157° 06' W., H. O. Charts 5736 and 1839) is a coral atoll which was discovered in 1802 by the American ship Palmyra. It was taken as a possession by the United States in 1898 as a part of the Territory of Hawaii. During the years that followed the island passed through various hands until the title was finally acquired by Leslie and Ellen Furland-Leo of Honolulu in 1922. In 1939 the United States Navy began constructing a defense base on Palmyra. During World War II the base was expended.

Later the Civil Aeronautics Administration leased the island for making meteorological observations. Finally, in about 1951 the island was turned back to the Fullard-Leo family.

The atoll consists of many small islets lying on a barrier reef which lies in the east and west direction. Originally the atoll consisted of about 50 small islets, having a total area of about 250 acres, in a horse shoe surrounding three lagoons which are known as West, Center and East lagoons. During the occupation by the Navy most of the islets were connected by causeways. The islets stand at an elevation of about 6 feet above sea level and are densely covered by vegetation. The islets are scattered over an area of about $5\frac{1}{2}$ miles east and west by $1\frac{1}{2}$ miles north and south. The largest islet is Cooper Island, having an area of about 16 acres and is located on the northern side of the atoll.

The West Lagoon is deep, up to 200 feet in places, providing large anchorage areas and an adequate turning basin. A dredged channel that leads through the barrier reef on the southwestern side of the atoll is the only boat entrance to the lagoon. The depth at the entrance to the channel is about 20 feet. Along the southern shore of Cooper Island, in the West Lagoon is a boat house, a dock for large vessels, a re-fueling pier and a seaplane ramp. A 5000 foot air craft landing strip and numerous buildings which are in various stages of deterioration are also located on Cooper Island. The remaining perimeter of the West Lagoon is comprised largely of shoal reef area which in some areas is completely out of water during low tide. The Central Lagoon is connected to the West Lagoon by a shallow channel, about 10 feet in depth, which has been dredged between the two lagoons. The Central Lagoon is adequate for small boat navigation, attaining a maximum depth of about 15 fathoms. The Central Lagoon is separated from the East Lagoon by a

narrow causeway which serves as a roadway between the northern and southern sides of the island. The East Lagoon has a maximum depth of about 23 fathoms but for the most part is surrounded by shallow reef areas. There are two or three small openings to the ocean along the northern and eastern ends of the East lagoon.

The barrier reef is about 8 miles long in the east and west direction, extending about $1\frac{1}{2}$ miles eastward of Portsmouth Point. Extending eastward for a distance of about 3 miles from Portsmouth Point is a coral bank with depths of about 4 to 6 fathoms. A broken reef extends about 1 mile westward of the western extremity of the barrier reef at the western end of the atoll. On the northern and southern sides the atoll is almost steep-to, the 100 fathom curve generally being within 1,000 yards of the barrier reef. From the air it will be seen that the barrier reef is interrupted along its entire perimeter with innumerable small surge channels.

The weather at Palmyra is very unfavorable. Rain squalls are sudden and frequent. The average annual rainfall varies from about 100 to 180 inches. The uncertainty of the weather presents a difficult problem in attempting to develop a collecting schedule. The humidity is high but not to the extent of being disagreeable. The temperature at the time we were at the island hovered around 30° C during the warmer part of the day. Since the northeast trades prevail with an average velocity of about 10 to 12 knots living at Palmyra is quite comfortable. A tropical storm hovered to the westward of the island because of the meeting of the northeast and southeast trades.

The turbidity of the water within the lagoon at Palmyra varies considerably depending upon the general climatic conditions at the time. However, for the most part the water within the lagoon is murky and undesirable for Aqua-lung work. The best areas to work in were found to be at the western

end of the atoll. The area immediately southwest of Sand Island was excellent for making underwater observations. The water temperature averaged about 28° C. The tides are at high water, full and change at 5 hours 03 minutes. Spring tides rise to a height of 2.4 feet.

The vegetation at Palmyra is dense. Most of the coconut palms were originally introduced but are now growing abundantly and propagating themselves. Ficus, tree hellebore, pandanus, naupaka, hoeli, ferns, herbs and vines flourish. The island has a unique insect fauna. Hermit crabs, and large land crabs are exceedingly numerous. Coconut crabs are present but not in large numbers. There is the usual variety of oceanic birds present.

ECOLOGICAL DATA ON COLLECTING AREAS

Station #1 - It was in this area where the C.G.C. Buttonwood anchored before unloading our equipment from the boat. The crew of the boat thoroughly covered this area by line fishing. Water depth was about 10 fathoms with probably a sandy bottom. The water was slightly murky. Small amounts of brown and green algae floated on the surface. Hook and line fishing in this area yielded large numbers of red snappers and small sand sharks. Water temperature 28° C.

Station #2 - Shallow reef area on west Lagoon side of Strawn Island. Reef and shore of coral sand and rocks. Some small, dead coral heads. No live coral observed. Green and brown algae along shore with slight growths on underwater rocks. Water temperature 28° C.

Station #3 - Shallow water passage way between ocean and East lagoon. Water depth one to four feet. Bottom predominantly of coral rocks and sand with some ooze. Steady current with changing tides. Large quantities of attached and floating green and brown algae.

- Station #4 - Off shore of small island N. of Sand Island. Shore of coral rocks, boulders and a small amount of sand. Small amount of algal growth. Bottom sandy at point of capture. Water temperature 28° C.
- Station #5 - Shallow reef area northwest of West Lagoon. Depth of water at mean high tide 2 to 4 feet. Bottom of sand and coral rock patches. Small amount of green and brown algae. Water temperature 29° C.
- Station #6 - Shallow reef area on south side of Strawn Island. Conditions as in Station #5. Water temperature 32° C.
- Station #7 - Tide pool on Strawn Island of approximately ten foot radius at low tide. Depth of water to three feet. Bottom of thick ooze. Very small amount of algae. Water temperature 32° C.
- Station #8 - Reef shelf southwest of Strawn Island. Depth of water 2 to 3 fathoms. Small amount of live coral and algae on edge of reef. Bottom sandy. Floating green and brown algae. Water temperature 28° C.
- Station #9 - Reef area, western end of atoll. Water 2 to 6 feet deep. Many dead coral heads. Small amount of live coral. Bottom composed of patches of sand, ooze and rocks. Small amounts of green and brown algae. Water temperature 28° C.
- Station #10 - Boat house slip. Water 10 to 12 feet deep. Steel pilings and metal wreckage with algal growth. Bottom predominantly sand. Water temperature 28° C.
- Station #11 - Shallow reef area north of Home Island, West Lagoon, 2 to 4 feet of water. A few small coral heads. Bottom of sand and rocks. Small amount of green and brown algae. Water temperature 28° C.

Station #12- Edge of shallow reef F. of Home Island, West Lagoon. Depth of water 2 to 10 feet. Bottom of rocks with some sand. Slight growth of algae. Shore of dead coral heads and boulders. Fairly strong current. Water temperature 27° C.

Station #13- Northside of Strawn Island. Conditions similar to station 5 with 6 to 12 inches of water.

Station #14- Northwest corner of Center Lagoon. Water depth 1 to 4 feet. Bottom of sand and ooze with scattered rocks and boulders. Some green and brown algae. Shore of sand and coral rocks. Water temperature 28° C.

Station #15- Reef edge in East Lagoon. 3 to 4 fathoms deep. Reef edge of coral boulders. Great deal of floating algae. Bottom of sand.

Station #16- Near entrance of Center Lagoon. Water depth approximately 20 feet. Bottom of coral sand. Shore of sand and rocks. Slight growth of algae. Water very murky. Water temperature 28° C.

Station #17- About 1 mile southwest of Sand Island. Depth about 7 fathoms. Bottom probably sand with scattered rocks. No obvious vegetation. Water temperature 28° C.

Station #18- About 500 meters west of Sand Island in channel. Water depth 2 to 4 fathoms. Bottom of coral sand, boulders, and live coral. Water very clear. No obvious vegetation. Water temperature 28° C.

Station #19- Shallow area near center of West Lagoon. Bottom of coral sand with some rocks. Water depth 2 to 3 fathoms. Water murky. No obvious plant growth. Water temperature 28° C.

Station #20- Northern tip of Sand Island at old pier. Water depth to 15 feet. Bottom of sand with scattered rocks and boulders. Slight growth of brown and green algae. Water murky with some current. No live coral. Water temperature 28° C.

Station #21- Coral shoal area, southwest of Sand Island. Depth of water to 20 feet. Bottom varies in different areas from sand with dead coral heads to complete covering of live coral. Small growth of algae. Concentrated population of fishes in various places. Water very clear except on outgoing tide when there is quite a strong current which brings murky water from lagoon. Conditions excellent for spearing and photography. Red snapper, parrotfish, eels, pompano and other reef fishes were abundant in this area. Water temperature 28° C.

Station #22- Shallow reef area east of Papali Island. Shore of sand, bottom of predominantly dead coral, slight growth of green and brown algae. Water depth 1 to 4 feet. Water temperature 28° C.

Station #23- Shallow reef 100 meters east of Bird Island. Shore of dead coral. Bottom of coral sand with some heads of dead or live coral. Some growth of microscopic algae. Water temperature 28° C.

GENERAL REVIEW OF COLLECTING ACTIVITIES

This survey was probably the most complete field study that we have made to date. Adequate personnel, collecting equipment, reefer facilities, plus the cumulative effects of past experiences were the primary contributing factors in making the survey a successful one.

Fishes at Palmyra were abundant both in numbers and variety. Palmyra has the largest red snapper population of any area that we have studied thus far. The red snappers of Palmyra are notoriously toxic and the material

collected should provide an adequate amount of the poison for future food chain studies. Three species of red snapper were found to be almost equally abundant, Lutjanus bohar, L. vaigiensis and L. gibbus. The young of L. vaigiensis were exceedingly common in the lagoon but the adults were to be found only on the outside and especially at the western end of the atoll. Snappers were readily taken by either hook and line or dynamite. Moray eels were plentiful but consisted largely of about three species, Gymnothorax pictus, G. javanicus and what appeared to be G. flavimarginatus. The most satisfactory method of collecting G. pictus was to go out on the reef during a low tide at night. With the use of a Coleman lantern and a trident spear large numbers of morays were captured in this manner. G. javanicus seems to prefer deeper water and is best captured with an arbaleta. Since morays have been the cause of a number of fatal intoxications elsewhere the moray eel population must be looked upon with suspicion until mouse tests demonstrate that they are safe to eat. Three species of puffers were observed, Arrothron hispidus, A. meleagris and A. nigropunctatus. Arrothron hispidus was very common, A. meleagris was only occasionally seen and only a single specimen of A. nigropunctatus was seen swimming in the shoal area at the west end of the atoll. Special effort was made to collect a large representative series of puffers. Strange to say not a single specimen of any of the sharp-nosed puffers was observed during the entire trip. Puffers are most easily collected by native spear. The parrotfishes are common and present in a great variety of species. Most of the parrots are considered to be edible by Mr. Otto Mortung, the resident agent at Palmyra, who claims to eat them whenever he gets the opportunity. Parrots are best captured by arbaleta. The shoal reef area at the western end of the atoll provides excellent parrotfish collecting for night-light spearfishing. Acanthurus triostegus and numerous other

species of surgeonfishes were exceedingly abundant. Particular attention was directed toward obtaining a large collection of A. triostegus from various different ecological areas at Palmyra since this was the species which had caused the outbreak of ichthyosarcotomism at Maui, T. H., on February 28, 1951 which involved 28 persons. Moreover, the A. triostegus had been imported from Palmyra. Large samples of algae were collected from the same areas in which the manini, A. triostegus, were observed feeding. This material will be used in the forth-coming food chain experiments. Mr. Hornung was uncertain as to the edibility of most of the surgeonfishes. There are at least two species of mullet, Mugil spp., which inhabit the lagoon. All of the mullet are said to be edible. Surmullet or goatfishes are common. Mulloidichthys spp. are considered to be non-toxic but Parupeneus spp. must be held under suspicion until further studies have been completed. Goatfishes were most easily captured by dynamite. Ulus or pompano, Caranx spp., are readily taken by trolling with spoons or feathers. The white ulus is commonly eaten and is a very fine food fish. However, the black ulus, probably Caranx melampygus, is considered to be toxic and reported to have caused a number of serious intoxications in the past. A number of specimens and species of white ulus were taken but despite every effort to capture the dark species we failed to obtain a single specimen. Three or four small, and two large specimens of the dark species were observed swimming about 500 yards west of Sand Island. The snout of the black ulus is concave in profile rather than convex as is the case of the white species. The coloration of the dark species during life is from a dark gray to almost black, both dorsally and ventrally, making a striking contrast to the other species. Groupers, Serranus spp., Cephalopholis argus, etc., were common and a large representative series were taken. Labrids did not appear to be very plentiful and only a few species were obtained.

Triggerfishes surprisingly enough were not present in large numbers, either in species or specimens. A few large specimens of Balistes flavimarginatus were observed swimming in some of the shallow areas of the lagoon but only a single small specimen was captured. Lethrinids were relatively common both in and outside of the lagoon and an excellent series was obtained by hook and line and dynamite. Two excellent specimens of Variola louti, seabass, were taken by dynamite. Siganids were present but not abundant. Pomacentrids were present but not as abundant as in the Marianas. A fair series of Butorifidus spp. were captured by spear and dynamite. In general the collecting was excellent and a total of about 1200 pounds of fishes were taken.

Numerous photographs, kodachrome transparencies, black and white and underwater movies were taken by Mr. Donald G. Ollie, our photographer. The underwater movies should prove to be of considerable help in making food chain studies. We used a 16 mm. Eastman Cine Special which was housed in a special underwater case that was designed and manufactured by Mr. Norman C. Bunker of our staff.

CARE AND SHIPMENT OF SPECIMENS

Very shortly after capture all specimens were placed in the reefer and quick frozen. The fishes were then transferred to plastic bags and packed in wooden boxes for shipment. Storage temperatures ranged from about 10 to 15° F. The boxes of specimens accompanied our staff on the return MATS flight to Honolulu. Thanks to Lieutenant Buchband arrangements had been previously made to provide us with dry ice for the return flight so the fishes remained frozen during transit. Upon arrival in Honolulu the specimens were immediately transferred to the Kilpatrick Cold Storage Plant. According to present plans the fishes are to be shipped to San Francisco Port of Embarkation via MATS and then to Long Beach via the Naval Supply Depot in Oakland. Arrangements

ments for the return shipment are being handled by the Office of Naval Research in Pasadena.

RECOMMENDATIONS

1. Consideration should be given toward obtaining a 12 to 14 foot fiberglass boat and a 10 horsepower Johnson outboard motor equipped with an inboard gas tank. A wooden boat is unsatisfactory for working around coral reefs. The gunnels of the boat should be equipped with a hand rail for use in diving. Additional Aqua-lungs and a small aircraft type of air compressor should be purchased. Additional snorkels and an underwater CO₂ gun are also needed.

2. Considerable attention should be given to the utilization of underwater movies in conducting future food chain studies.

3. Further study must be given toward establishing a field station on one of the Pacific islands if the basic cause of fish poisoning is to be determined. However, this recommendation in no way obviates the necessity of continuing the current epidemiological and distributional studies. These latter investigations from the viewpoint of public health and survival work are important and should be continued.

4. Our collecting techniques must be improved. It is recommended that on the next investigation that one or two scientists from other organizations be invited to participate in the survey. Individuals should be selected who are intimately acquainted with deep water poisoning techniques and the use of the trammel net.

5. Study is now being given to the possibility of conducting the next field investigation at Eniwetok during the spring or summer of 1954. Word has just been received from the Division of Biology and Medicine of the Atomic Energy Commission in Washington, D.C. that they are planning on establishing

a biological station at Eniwetok and that we are invited to participate in the program. A few days after receiving this invitation we also learned that there had been an outbreak of cholera poisoning at Eniwetok among Navy personnel involving six persons. One of the men died in the Queens Hospital just prior to our return.

SUMMARY

1. An investigation was conducted on the poisonous and venomous fishes of Palmyra Island during the period of 13 April to 2 May 1953. Members of the staff from the School of Tropical and Preventive Medicine consisted of Bruce W. Halstead, Norman C. Barker, Leonard S. Kuninobu, Robert L. Smith, F. Douglas Horton, and Donald G. Ollis.
2. Palmyra Island was selected because of its reputation as an important endemic area for poisonous fishes.
3. A large representative collection of Palmyra fishes were obtained, having a gross weight of about 1200 pounds. The specimens are in cold storage in Honolulu and are scheduled to be shipped to Long Linda within the near future. The toxic nature of the specimens collected will not be known until screening studies have been completed.
4. While on Palmyra arrangements were made with Mr. Phil Palmer, the resident agent of the Fanning Island Plantation, Fanning Island, for a shipment of representative reef fishes of Fanning Island. Word has been received that a collection of Fanning Island reef fishes has been made. The fishes are now frozen and awaiting shipment to the United States. An English concern has agreed to handle the shipping on a gratis basis. This additional material will make a valuable contribution to our study of the Line Island reef fishes.
5. A shipment of frozen Line Island fishes has also just been received from

Mr. Joseph King of the Pacific Oceanic Fishery Investigations of the Fish and Wildlife Service in Honolulu. The Fish and Wildlife Service has consistently rendered us an invaluable support for the last three years and their cooperation has been greatly appreciated.

ACKNOWLEDGEMENTS

Appreciation is expressed to Captain Miller, Horton Air Force Base, San Bernardino, California, Colonel Roberts, Port of Embarkation, San Francisco, California, and to Colonel Rawles, Port of Embarkation, Honolulu, for their cooperation in the handling of equipment and personnel.

Special thanks are due to the Commander of the 11th Coast Guard District, Lieutenant Commander G. W. Sohn, the officers and the crew of the C.G.C. Butternut for the transportation of equipment and personnel from Honolulu to Palmyra.

The kind cooperation and generous hospitality of Mr. Leslie V. Fullard-Lee and Mrs. Ellen Fullard-Lee, the owners of Palmyra Island, are sincerely appreciated. We also wish to thank Mr. Otto Horning, the resident agent at Palmyra Island, for his cooperation and aid during our stay on the island.

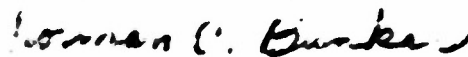
Major Brunner and his associates of the Pacific Division of IATS at Hickam Field, Honolulu, are to be thanked for arranging the special flight back to Honolulu.

Finally, once again we wish to express our appreciation to the Office of Naval Research in Pasadena for their aid in the return shipment of the fishes to Los Angeles.

Respectfully submitted,



Bruce W. Halsted, M.D.



Herman C. Bunker.

