TITLE

Recruitment, Growth, and Developmental Habitat Requirements of Green Turtles in Their Nearshore Foraging Pastures (MR/R-26)

PRINCIPAL INVESTIGATOR

George H. Balazs

DURATION

June 1, 1983 through May 31, 1984

MOTIVATION

Previous research carried out by this investigator has yielded considerable information on the life history and ecology of green turtles (Chelonia mydas) at their breeding and basking areas in the remote Northwestern Hawaiian Islands (Balazs, 1976, 1980a, 1980b; Dizon and Balazs, 1982; Whittow and Balazs, in press). As part of the Northwestern Hawaiian Islands fisheries investigations undertaken during SGY 1977-78 through SGY 1979-80, this work fulfilled the program's basic need for management-oriented data on green turtles in the northwestern segment of the archipelago.

A significant and somewhat unexpected finding of these past studies was the identification of key coastal sites along the Ka'u District on the island of Hawaii that constitute highly productive foraging habitat for both immature and adult green turtles (Figure 1). These rich algal pastures at the extreme southeastern end of the archipelago have produced the most rapid growth rates of Hawaiian green turtles thus far recorded or any other green turtle population examined elsewhere to date (Balazs, 1979, 1982). It is therefore likely that turtles living along the Ka'u coastline are making major contributions to the seasonal migratory breeding colony that occurs at French Frigate Shoals in the Northwestern Hawaiian Islands. A greater proportion of recruits to the breeding colony can be expected to result from these superior foraging areas. In addition, higher levels of reproduction can be expected once the turtles reach sexual maturity, since the interval needed between breeding migrations (2 years or more) will be shorter than for turtles residing at less productive coastal sites. The reasons for the higher rates of growth in the foraging pastures of the Ka'u District are not known at present. The principal food source used by the turtles is believed to be Pterocladia capillacea, a red alga that thrives along certain lava rock coastlines where freshwater percolates into the ocean. This submarine discharge of groundwater may very well supply elevated levels of nutrients that promote algal growth (Johannes, 1980).

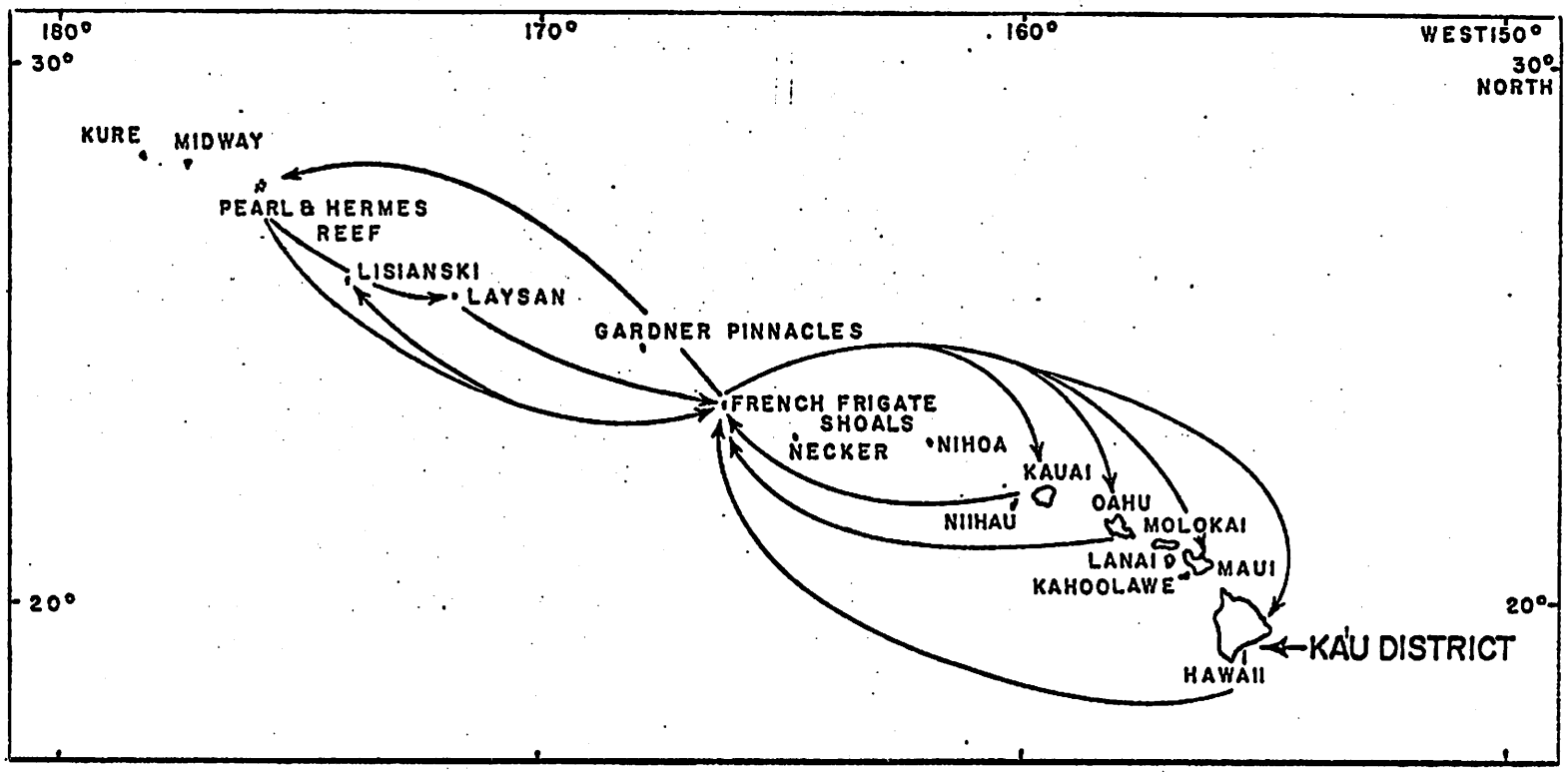

Figure 1. Map of the Hawaiian Archipelago showing the location of the Ka'u District on the island of Hawaii at the southeastern end of the chain. The various arrows show the breeding migrations of adult green turtles to and from French Frigate Shoals as documented by tagging studies.

Comparatively little work has been focused on green turtles, or any other sea turtle species, while they are in foraging pastures where they spend most of their life. In addition to the author's own work here in Hawaii (Balazs, 1979, 1982), accounts of foraging pasture studies are limited to Schmidt (1916) for the Virgin Islands, Carr and Caldwell (1956) for west Florida, Burnett-Herkes (1974) for Bermuda, Limpus and Walter (1980) for Australia, and Mendonca (1981) and Mendonca and Ehrhart (1982) for Mosquito Lagoon in east Florida. Bjorndal (1980) and Mortimer (1981) have presented information on the feeding ecology of green turtles at several sites in the Caribbean.

It is clearly far more difficult and time consuming to undertake research of sea turtles in their marine habitat, as opposed to nesting sites where the adult females converge on land and can be easily observed and tagged. The voluminous body of literature dealing with the tagging of nesting turtles reflects this important point. Nevertheless, there is now widespread agreement among sea turtle researchers and resource managers that studies must be directed toward immature and adult turtles in foraging pastures if further essential knowledge of the species is to be acquired (Hirth, 1971; Carr et al., 1978; Hopkins and Richardson, 1981; Bjorndal, 1982).

Nearly all sea turtles are currently protected under the U.S. Endangered Species Act. Although population declines have occurred as the result of several adverse factors, there is nevertheless good reason to believe that green turtles, especially in the Hawaiian islands, can be restored and properly managed for the benefit of both man and turtles. Recent work by Thayer et al. (1982) indicates that green turtles are likely to play a significant role in the cycling of nutrients by reducing the decomposition time of the marine vegetation used as forage. This "short-circuiting" of the detritus cycle represents a beneficial link between the abundance of turtles in nearshore habitat and the enrichment of the ecological system as a whole.

The overall motivating factor of this proposal is the recognized need for specific information on green turtles in their nearshore foraging pastures. The question then is "where" can it best be conducted and with what research talents. The advantages of using foraging pastures along the Ka'u District as the site of an in-depth, year-long, investigation are summarized as follows:

1. The comparatively rapid growth rates exhibited by turtles living in the Ka'u pastures, and the potentially major contribution they make to the breeding colony at French Frigate Shoals
2. The presence of sufficient numbers of both adults and immature turtles aggregated at specific sites along the Ka'u coastline so as to make the research cost effective

3. The substantial amount of previous tagging conducted at French Frigate Shoals, the breeding site for adult turtles living in Ka'u pastures
4. The presence of a pool of over 100 immature turtles that were captured, tagged, measured, and released during an earlier exploratory work in the Ka'u pastures by this investigator and by students of the Marine Option Program at the Hilo campus of the University of Hawaii
5. The accessible nature of these pastures and their relative safety as an area to undertake research (i.e., few sharks and good weather)
6. The investigator's proven ability to study, capture, and tag turtles in the marine environment
7. Superior corrosion-proof turtle tags made from Inconel alloy (Balazs, 1982), specially designed by the investigator, will be available for use. The investigator arranged to have an experimental batch manufactured in 1976 by the National Band and Tag Company of Newport, Kentucky
8. The relatively undeveloped and undisturbed nature of the ecological system that comprises the Ka'u foraging pastures
9. The demonstrated goodwill and assistance provided by the local residents of the Ka'u District to sea turtle researchers
10. The availability of a portable scuba compressor, tanks, an inflatable boat, outboard motors, an underwater camera, and other basic equipment from the Northwestern Hawaiian Islands Fisheries Investigations Program which can be used
11. The marking conducted in 1982 on 1,300 hatchlings at French Frigate Shoals using a promising scute grafting, or "living tag," procedure developed by Hendrickson and Hendrickson (1981). The recruitment of some of these known-age turtles from the pelagic environment is expected to occur in the Ka'u pastures during the 12-month period covered by this proposal.

Other agencies which have interests and responsibilities in the management of Hawaiian green turtles are the U.S. Fish and Wildlife Service and the Hawaii Department of Land and Natural Resources. The principal investigator's salary for the duration of this proposed research (SGY 1983-84) will be paid by the National Marine Fisheries Service, Southwest Fisheries Center, Honolulu Laboratory which has cooperative responsibility for management of endangered marine animals as well as for monitoring threatened species such as green turtles.

GOALS

Overall

The overall project goal is to acquire important baseline data on the ecology and population dynamics of green turtles living in the rich foraging pastures along the Ka'u District of the island of Hawaii. This information will have direct application to the future management of Hawaiian as well as other populations of green turtles.

Specific

1. To locate, map, and characterize the specific habitat being used by green turtles for foraging and sleeping purposes
2. To sample and determine the levels of nutrients contained in the submarine groundwater discharge occurring along the coastline
3. To census the resident turtle stocks by size category (juvenile, sub-adult, and adult) at each of the key habitat sites
4. To estimate the carrying capacity of the available habitat for green turtles to predict how much the local aggregations could expand if recruitment was not a limiting factor
5. To substantially strengthen and refine the existing body of growth data by recapturing and remeasuring immature turtles that were tagged along this coastline at an earlier date
6. To determine the rates of recruitment of juveniles from the pelagic to the nearshore habitat that occur during the course of the 12-month study
7. To identify the specific food sources being utilized by the turtles as well as the approximate daily levels of consumption by each size category
8. To identify and, to the extent possible, quantify the factors responsible for natural mortality of the turtles
9. To ascertain the effectiveness of the "living tag" marking procedure on those hatchlings that arrive as new juvenile recruits along the coastline

METHODS

The basic methodology used to accomplish the project's goals will involve six study visits to the Ka'u District by the principal investigator for a duration of 10 to 15 days each. A small field camp will be established during each trip in proximity to the area being intensively investigated. Much of the research will revolve around the capture of turtles, either by hand using scuba or by setting large-mesh tangle nets at strategic pathways.

between feeding and sleeping areas. Tangle nets will be carefully monitored to prevent injury to the turtles. A large proportion of this work will have to be conducted at night when the turtles are more susceptible to capture. Standard body measurements and weights will be recorded for all turtles. The dietary components will be determined by sampling the stomach contents through a plastic tube inserted down the esophagus (Balazs, 1980c). All turtles will be double tagged, or retagged, using numbered Inconel alloy tags bearing a return mailing address.

Key feeding sites will be located by hiking along the coastline and making direct observations along the shallow (<5 m) nearshore waters where algal growth is most abundant. Lava rock cliffs along the area will provide excellent lookouts for using binoculars to spot turtles while they are foraging. Green turtles frequently swim to the surface to breath while they are actively feeding.

Underwater surveys with scuba and by towing a diver from an inflatable boat will be carried out to compile detailed habitat maps of foraging and sleeping areas. The algae and invertebrate growth available to turtles as forage at each benthic community will be sampled and identified. Larger samples will also be collected to estimate standing crop densities of Pterocladia capillacea and other algae found to be heavily consumed by turtles.

Permanent transects will be designated and mapped to aid in censusing aggregations of turtles. The number of turtles of each size category will be counted during surveys with scuba (or while being towed) for a given time over a set distance. The generally excellent clarity of the ocean water along the Ka'u coastline will enhance this portion of the study.

Information on natural mortality that results from predation or disease will be tabulated through observations of lesions, scars, and any pathological signs present on captured or sighted turtles. At select sites, several large baited hooks will be set to sample sharks and examine their stomach contents for the presence of turtle remains.

Samples of the groundwater discharge occurring in the nearshore waters will be taken and analyzed for nitrates, phosphorus, and other nutrients. Sites of discharge in the Ka'u District are easily located along the lower intertidal zone. Nutrient levels of the seawater near forage areas will also be sampled as well as at sites along the Ka'u coast where there are no foraging pastures or resident turtles.

The Marine Option Program of the University of Hawaii at Hilo will be substantially involved in all aspects of the project. Research activities will be used by undergraduate students as partial credit toward certification in the Marine Option Program. A limited number of stipends will be made available for

financial compensation to these students. Dr. Walter C. Dudley will coordinate this aspect of the project.

Cooperative assistance in the form of in-kind services and support is anticipated from the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the Hawaii Department of Land and Natural Resources, and the U.S. National Park Service. A portion of the Hawaii Volcanoes National Park is located along the Ka'u coastline.

BUDGET JUSTIFICATION

Travel between Honolulu and the Ka'u District is essential to accomplish the proposed research and oversee field activities undertaken in cooperation with undergraduate students of the Marine Option Program.

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NOAA FORM 90-4
(2-74)

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

FORM APPROVED:
O.M.B. NO. 41-R2779
EXPIRES: 12-31-78

SEA GRANT BUDGET

GRANTEE	GRANT/PROJECT NUMBER
University of Hawaii	MR/R-26
PRINCIPAL INVESTIGATORS	**DURATION (months)**
George H. Balazs	12 06/01/83 - 05/31/84

	MAN-MONTHS		SEA GRANT FUNDS	GRANTEE SHARE
A. SALARIES AND WAGES				
1. SENIOR PERSONNEL				
a. *(Co)* Principal Investigator				000*
b. Associates *(Faculty or staff)*				
Sub Total				000
2. OTHER PERSONNEL				
a. Professionals				
b. Research associates				
c. Research asst., grad. students				
d. Prof. school students				
e. Pre-Bac. students			6,050	
f. Secretarial-clerical				
g. Technical-shop				
h. Casual hire			300	
Total Salaries and Wages			6,350	
B. FRINGE BENEFITS *(When charged as direct cost)*			92	
Total Salaries, Wages, and Fringe Benefits *(A and B)*			6,442	
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			1,200	
E. TRAVEL				
1. Domestic – U. S. and its Possessions *(Inc. Puerto Rico)* 1.			4,350	
2. International 2.				
Total Travel			4,350	
F. PUBLICATION AND DOCUMENTATION COSTS				
G. OTHER COSTS				
1. Computer Costs				
2. Lab use fee			135	
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
Total Other Costs			135	
TOTAL DIRECT COSTS *(A through G)*			12,127	
INDIRECT COSTS *(On Campus % of)*				
(Off Campus Research 23.00% of 12,127 *)*			2,789	
Total Indirect Costs			2,789	
TOTAL COSTS			14,916	
ROUNDED TO				

NOAA FORM 90-4 (2-74)

*5 months time of George H. Balazs, federally funded Fishery Biologist of the National Marine Fisheries Service, is not included.

SEA GRANT PROJECT SUMMARY

UNIVERSITY OF HAWAII SEA GRANT COLLEGE PROGRAM

TITLE: Recruitment, Growth, and Development and Habitat Requirements of Green Turtles in their Nearshore Foraging Pastures

PROJECT NUMBER: MR/R-26, SGY 16
REVISION DATE:
GRANT NUMBER:
INITIATION DATE: 06/01/83
SUB PROGRAM:
COMPLETION DATE:08/31/84

PRINCIPAL INVESTIGATOR: George H. Balazs
AFFILIATION: Honolulu Laboratory National Marine Fisheries Service
ASSOC. INVESTIGATOR: Walter Dudley
AFFILIATION: University of Hawaii- Hilo

FED FUNDS TO DATE:	$	MATCH FUNDS TO DATE:	$ (5 months of PI's salary)
LAST YEAR'S FED FUNDS:	$	LAST YEAR'S MATCH FUNDS:	$
CURRENT FED FUNDS:	$ 14,916	CURRENT MATCH FUNDS:	$
RELATED PROJECTS:		PARENT PROJECTS:	

SEA GRANT CLASSIFICATION: 07. Biological Oceanography

KEYWORDS: sea turtles, habitat, ecology, management

OBJECTIVES:

Overall To acquire in-depth baseline data on the ecology and population dynamics of green turtles, Chelonia mydas, living in the rich foraging pastures along the Ka'u District coastline of the island of Hawaii.

Specific

1. To locate, map, and characterize nearshore habitats used by green turtles
2. To determine nutrient levels in the submarine groundwater discharges of nearshore habitats
3. To census resident turtle stocks
4. To estimate the carrying capacity of habitats used by turtles
5. To compile further dataon growth rates of immature turtles
6. To determine recruitment rates of juvenile turtles
7. To identify food sources
8. To identify natural mortality factors
9. To ascertain the effectiveness of a scute grafting technique for marking hatchlings

METHODOLOGY

Live capture of turtles for tagging and data collection using tangle nets and scuba gear.

RATIONALE:

The information obtained will be used by the National Marine Fisheries Service, the Hawaii Department of Land and Natural Resources, the Coastal Zone Management Program, and the U.S. Fish and Wildlife Service to make sound long-range management decisions relating to green turtles and their marine habitat in the main Hawaiian Islands. The information will also be beneficial to the management of green turtles occurring elsewhere in the world.

ACCOMPLISHMENTS:

During the project 109 turtles were captured and studied, including 94 immatures, 6 adult females, and 9 adult males. 27 short-term and 14 long-term recaptures were made, yielding growth data ranging up to 5 years in duration. To the extent that it proved feasible, data were collected to fulfill all major objectives set forth for the project.

BENEFITS:

Enhanced scientific understanding and management of the green turtle in Hawaiian waters.

For Sea Grant Use Only

Sea Grant Year: 16
Project Number: MR/R-26

STUDENT INFORMATION FORM

Project Title Recruitment, Growth, and Developmental Habitat Requirements of Green Turtles in their Nearshore Foraging Pastures

Principal Investigator(s) George H. Balazs and Walter Dudley

In order to document the National Sea Grant College Program's total impact on training and education, we are required to report all students supported in any way by Sea Grant. Please help us by providing the following information on the students involved in your project.

Student	Check (✓) One		Discipline	Earned	Month/ Year
	Undergraduate	Graduate			
1. Ariga, Hitoshi	X				
2. Bernard, Nancy D.	X				
3. Brooks, William	X				
4. Doll, Chris	X				
5. Engle, Dean	X				
6. Fong, Richline P.	X				
7. Hall, Lisa	X				
8. Kaichi, Miles	X				
9. Kuamoo, Darrell	X				
10. Laube, Bob	X				
11. Mazarakis, Diane M.	X				
12. Mazarakis, Loretta A.	X				
13. Nevins, Randy L.	X				
14. Orcutt, William	X				

We also need to document our impact on the work force. Please provide the following information on Sea Grant supported graduate and undergraduate students who found employment after leaving your project.

Student	Degree Earned	Discipline	Firm	Position

For Sea Grant Use Only

Sea Grant Year: 16
Project Number: MR/R-26

PUBLICATIONS INFORMATION FORM

The following publication reports the research results of:

Project Title Recruitment, Growth, and Development Habitat Requirements of Green Turtles in their Nearshore Foraging Pastures

Sea Grant Institutional Grant No. NA81AA-D-00070

Principal Investigator(s) George H. Balazs and Walter Dudley

Project Duration 6/83 -8/84

Title of Publication M.O.P. goes turtling on the Big Island

Author(s) Nancy Bernard

Publication Date March 15, 1984

Publisher (if other than Sea Grant, specify cooperating agency/department/institute "Imua Hilo" (Univ. Hawaii at Hilo)

Publication No. Volume 3, Number 2

Type of Report:

_____ advisory	_____ journal article
_____ bulletin	X newsletter
_____ conference paper	_____ technical
_____ flyer	_____ other _____ (specify)

NOTE: Please duplicate this form if more than one report is pending or was published.

For Sea Grant Use Only

Sea Grant Year: 16
Project Number: MR/R-26

PUBLICATIONS INFORMATION FORM

The following publication reports the research results of:

Project Title Recruitment, Growth, and Developmental Habitat Requirements of Green Turtles in their Nearshore Foraging Pastures

Sea Grant Institutional Grant No. NA81AA-D-00070

Principal Investigator(s) George H. Balazs and Walter Dudley

Project Duration 6/83 - 8/84

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Author(s) Nancy Bernard

Publication Date March 15, 1984

Publisher (if other than Sea Grant, specify cooperating agency/department/institute

Seawords (news of the Marine Option Program)

note- same article appeared in Imua Hilo, March 15, 1984, volume 3, number 12

Publication No. Issue no. 4

Type of Report:

_____ advisory	_____ journal article
_____ bulletin	__X__ newsletter
_____ conference paper	_____ technical
_____ flyer	_____ other _____ (specify)

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UHSG Rev. 08/84

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Sea Grant Year: 16
Project Number: MR/R-26

PUBLICATIONS INFORMATION FORM

The following publication reports the research results of:

Project Title Recruitment, Growth, and Developmental Habitat Requirements of Green Turtles in their Nearshore Foraging Pastures

Sea Grant Institutional Grant No. NA81AA-D-00070

Principal Investigator(s) George H. Balazs and Walter Dudley

Project Duration 6/83 - 8/84

Title of Publication Big Island MOP news

Author(s) Walter Dudley

Publication Date April 6, 1984

Publisher (if other than Sea Grant, specify cooperating agency/department/institute

Seawords (news of the Marine Option Program)

Publication No. Issue no. 5

Type of Report:

_____ advisory	_____ journal article
_____ bulletin	_X_ newsletter
_____ conference paper	_____ technical
_____ flyer	_____ other _____ (specify)

NOTE: Please duplicate this form if more than one report is pending or was published.

UHSG Rev. 08/84

For Sea Grant Use Only

Sea Grant Year: 16
Project Number: MR/R-26

PUBLICATIONS INFORMATION FORM

The following publication reports the research results of:

Project Title Recruitment, Growth, and Developmental Habitat Requirements of Green Turtles in their Nearshore Foraging Pastures

Sea Grant Institutional Grant No. NA81AA-D-00070

Principal Investigator(s) George H. Balazs and Walter Dudley

Project Duration 6/83 - 8/84

Title of Publication Tagging turtles may save their lives

Author(s) Rick Klemm

Publication Date September 1984

Publisher (if other than Sea Grant, specify cooperating agency/department/institute

Manulani, the magazine of Mid Pacific Air

Publication No. Volume 4, Number 5

Type of Report:

_____	advisory	_____	journal article
_____	bulletin	_____	newsletter
_____	conference paper	_____	technical
_____	flyer	_X_	other airline magazine (specify)

NOTE: Please duplicate this form if more than one report is pending or was published.

For Sea Grant Use Only

Sea Grant Year: 16
Project Number: MR/R-26

PUBLICATIONS INFORMATION FORM

The following publication reports the research results of:

Project Title Recruitment, Growth, and Developmental Habitat Requirements of Green Turtles in their Nearshore Foraging Pastures

Sea Grant Institutional Grant No. NA81AA-D-00070

Principal Investigator(s) George H. Balazs and Walter Dudley

Project Duration 6/83 - 8/84

Title of Publication Learning about green turtles' life styles

Author(s) Rick Klemm

Publication Date scheduled for October 1984

Publisher (if other than Sea Grant, specify cooperating agency/department/institute Makai (University of Hawaii Sea Grant Extension)

Publication No. Volume 16, Number 10

Type of Report:

X	advisory	____	journal article
X	bulletin	____	newsletter
____	conference paper	____	technical
____	flyer	____	other ____ (specify)

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