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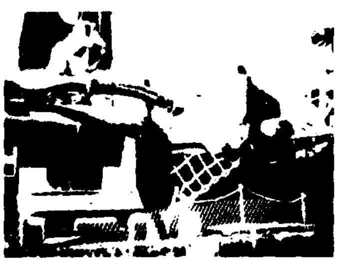

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PROCEEDINGS OF THE NATIONAL WORKSHOP ON METHODS TO MINIMIZE DREDGING IMPACTS ON SEA TURTLES

11 and 12 May 1988
Jacksonville, Florida

Compiled by

Dena D. Dickerson, David A. Nelson

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

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The US Army Corps of Engineers (CE) sponsored the "National Workshop on Methods to Minimize Dredging Impacts on Sea Turtles," held on 11-12 May 1988 in Jacksonville, FL, to focus on national concerns about dredging effects on sea turtles with specific reference to dredging operations in Cape Canaveral and King's Bay ship channels. The primary objective of the workshop was to identify methods that would prevent further sea turtle mortalities by dredges. The workshop addressed both biological and engineering aspects of the subject through formal presentations, group discussions, and subgroup sessions. The workshop conclusions proposed several methods of immediate and long-term actions as well as identified areas of needed information. Participants included 71 representatives from the CE, National Marine Fisheries Service, US Fish and Wildlife Service, US Navy, dredging industry, universities, and other related support agencies and organizations.

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PREFACE

This report summarizes the results of a workshop entitled "National Workshop on Methods to Minimize Dredging Impacts on Sea Turtles" held in Jacksonville, FL, on 11 and 12 May 1988. The purpose of the workshop was to identify and assess both biological and engineering methods to minimize dredging impacts on sea turtles.

The workshop was sponsored by the US Army Engineer District, Jacksonville (SAJ), and conducted by Mr. David A. Nelson and Ms. Dena D. Dickerson, Coastal Ecology Group (CEG), Environmental Resources Division (ERD), Environmental Laboratory (EL), of the US Army Engineer Waterways Experiment Station (WES). Additional workshop planning was done by Mr. Stephen A. Berry, Dr. Jonathan D. Moulding, and Mr. James D. Hilton, SAJ, and Dr. Tyrrell A. Henwood, National Marine Fisheries Service. Msses. Karen Polson and Gail Seidler, SAJ, provided secretarial assistance, and Mr. Charles E. Dickerson, Jr., WES, provided equipment assistance during the workshop. This report was compiled by Ms. Dickerson and Mr. Nelson and was edited by Ms. Lee T. Byrne, Information Technology Laboratory, WES.

Initial efforts were supported by the Environmental Effects of Dredging Programs with Dr. Robert M. Engler, Program Manager, and Mr. Thomas R. Patin, Assistant Program Manager. This work was performed under the general supervision of Mr. Edward J. Pullen, Chief, CEG; Dr. Conrad J. Kirby, Chief, ERD; and Dr. John Harrison, Chief, EL.

The Commander of SAJ was COL Robert _ Herndon. Commander and Director of WES during publication of this report was COL Larry B. Fulton, EN. Dr. Robert W. Whalin was Technical Director.

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Diane E. Ashton,* US Army Corps of Engineers, Planning Division, CEHMNPD-RE, New Orleans District, P.O. Box 60267, New Orleans, LA 70160-0267 (504-862-1735)

Clyde Aston, US Army Corps of Engineers, CESAJ-CO-ON, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-2539)

Gerald Atmar, US Army Corps of Engineers, Planning Division, CESAJ-PD, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-2615)

Phillip Baumgardner, US Army Corps of Engineers, CESAJ-CO-P, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-2076)

Lucy Beebe, P.O. Box 1457, Fernandina Beach, FL 32034 (904-261-8105)

Rebecca Bell, P.O. Box 3127, Jekyll Island, GA 31520 (912-264-7474)

Stephen A. Berry, US Army Corps of Engineers, CESAJ-CO-ON, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-1131)

Elizabeth Bishop, Public Works Dept., Engineering Division (Code N523 Bishop), Naval Submarine Base, Kings Bay, GA 31547 (912-673-2751)

Karen A. Bjorndal, Center for Sea Turtle Research, Department of Zoology, University of Florida, Gainsville, FL 32611 (904-392-1250)

Alan Bolten, Center for Sea Turtle Research, Department of Zoology, University of Florida, Gainesville, FL 32611 (904-392-5194)

Cleve Booker,* Department of Biological Sciences, University of Central Florida, P.O. Box 25000, Orlando, FL 32816 (904-275-2970 or 2141)

Rea Boothby,* US Army Corps of Engineers, Jacksonville District, Room 963, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-3453)

Robert Bridgers, Public Works Department, Engineering Division (Code N521 Bridgers), Kings Bay, GA 31547 (912-673-4709)

Paul Christian, OGA-MAREX, P.O. Box 2, Brunswick, GA 36523 (912-264-7268)

Lisa Conger, 436 Bailey St., Athens, GA (404-549-3778)

Dena Dickerson, US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199 (601-634-3816)

---

* Registered but unable to attend.

Mary Duffy, Fernandina Beach, FL (904-261-2697)

Stan Ekren, Great Lakes D&D, 9432 Bay Meadows Rd., Suite 150, Jacksonville, FL 32256 (904-737-2739)

Byron Farley, US Army Corps of Engineers, CESAJ-EN-DL, Jacksonville, FL 32232-0019 (904-791-2436)

Joe Ferris, Institute of Ecology, University of Georgia, Athens, GA 30602 (404-542-2968)

T. Allan Garratt, US Army Corps of Engineers, Savannah District, 100 W. Oglethorpe Ave., Savannah, GA 31401-3604 (912-944-5058)

Roger H. Gerth, US Army Corps of Engineers, Mobile District, P.O. Box 2288, Mobile, AL 36628-0001 (205-694-3709)

Linda Glenbosk, US Army Corps of Engineers, New Orleans District, OD-Project Branch-Navigation Section, P.O. Box 60267, New Orleans, LA 70160-0267 (504-862-2516)

Kenneth Graham, Dept. of the Interior, Minerals Management Service, 1201 Elmwood Park Blvd., New Orleans, LA 70123 (504-736-2852)

Patricia Hanson, US Army Corps of Engineers, CESAJ-CO-ON, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-3729)

Keith A. Harris, US Army Corps of Engineers, Savannah District, CESASPD-EI, Environmental Resources Branch, P.O. Box 889, Savannah, GA 31402-0089 (912-944-5793)

Robert G. Hauch, US Corps of Engineers, Galveston District, P.O. Box 1229, Galveston, TX 77553-1229 (409-766-3964)

Tyrrell A. Henwood, National Marine Fisheries Service, Southeast Region, 9450 Roger Blvd., Duval Building, St. Petersburg, FL 33702 (813-893-3366)

James D. Hilton, US Army Corps of Engineers, Jacksonville District, CESAJ-CO-O, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-1123)

Leon Hrabovsky, T. L. James & Co., P.O. Box 826, Kenner, LA 70063 (504-467-6000 ext. 208)

Alan Huff, Florida Dept. of Natural Resources, Bureau of Marine Science and Technology, 100 8th Avenue, S.E., St. Petersburg, FL 33701-5095 (813-896-8626)

Brian Hughes, US Army Corps of Engineers, Jacksonville District, CESAJ-EN-DL, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-2520)

Chuck Hummer,* US Army Corps of Engineers, Dredging Division, 20 Mass. Ave., N.W., Washington, DC 20314-1000 (202 272-0397)

* Registered but unable to attend.

D. L. Hussin, Great Lakes D&D, 2122 York Rd., Oakbrook, IL 60521 (312-574-3000)

G. William James III,[*] T. L. James & Co., Box 826, Kenner, LA 70063 (504-467-6000)

Jan Johnson, USA Sea Turtle Campaign, Greenpeace Southeast, P.O. Box 50489, Jacksonville Beach, FL 32240 (904-241-4310)

Drew Kendall, P.O. Box Z, Brunswick, GA 31523 (912-264-7268)

Edward Klima,[*] National Marine Fisheries Service, 4700 Avenue U, Galveston, TX 77551-5997 (409-766-3500)

Walter Lee, Gulf Coast Trawling Co., P.O. Box 10, Kenner, LA 70063 (504-464-9440)

Jacob W. Lehman, US Dept. of Interior, Gulf of Mexico OCS Regional Office, 1201 Elmwood Park Blvd., New Orleans, LA 70123-2394 (504-736-2779)

Brian Lindholm, Great Lakes Dredging, P.O. Drawer K, Staten Island, NY 10303 (718-981-2700)

Peter Lutz, Rosensteil School of Marine and Atmospheric Science, Univ. of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149 (305-361-4151)

Erik Martin, Applied Biology, Inc., P.O. Box 974, Jensen Beach, FL 34958 (407-334-3729)

Herbie A. Maurer,[*] US Army Corps of Engineers, Galveston District, CESWG-CO-M, P.O. Box 1229, Galveston, TX 77553-1229 (409-766-3966)

Rick Medina,[*] US Army Corps of Engineers, Galveston District, P.O. Box 1229, Galveston, TX 77553- 1229 (409-766-3962)

Cecelia Miles, 1023 N. Fletcher Ave., Fernandina Beach, FL (904-277-3947)

Vincent Montante, US Army Corps of Engineers, Dredging Division, 20 Mass. Ave., N.W., Washington, DC 20314-1000 (202-272-0397)

Jonathan D. Moulding, US Army Corps of Engineers, Jacksonville District, CESAJ-PD-E, Environmental Resource Branch, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-2286)

David Nelson, US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199 (601-634-3816)

Rudy Nyc, US Army Corps of Engineers, CESAD-PR-R, 510 Title Bldg., S.W., Atlanta, GA 30335-6801 (404-331-4619)

---

* Registered but unable to attend.

James O'Hara, Environmental and Chemical Science, Inc., P.O. Box 1393, Aiken, SC 29802 (803-652-2206)

Chuck Oravetz, National Marine Fisheries Service, Southeast Region, 9450 Roger Blvd., Duval Building, St. Petersburg, FL 33702 (813-893-3366)

Michael R. Palermo, US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199 (601-634-3753)

Earl Possardt, US Fish and Wildlife Service, 3100 University Blvd., Jacksonville, FL 32216 (904-791-2580)

Susan Ivester Rees, US Army Corps of Engineers, Mobile District, P.O. Box 2288, Mobile, AL 26628-0001 (205-690-2724)

Lizabeth Rhodes, US Army Corps of Engineers, Jacksonville District, CESAJ-PD, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-1691)

James I. Richardson, Georgia Marine Turtle Research Program, Institute of Ecology, University of Georgia, Athens, GA 30602 (404-542-2968)

Terrell W. Roberts, US Army Corps of Engineers, Environmental Resources Branch, P.O. Box 1229, Galveston, TX 77553 (409-766-3035)

Paul Schmidt, US Army Corps of Engineers, CESAJ-RD, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-2503)

John Seidler, Jr., US Army Corps of Engineers, CESAJ-CO-NF, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-354-5442)

Christopher Slay, University of Georgia, Institute of Ecology, 792 Little Oconee St., Athens, GA 30607 (404-542-2968)

Edward Standora, State University College, 1300 Elmwood Ave., Buffalo, NY 14222 (716-878-5008)

Ronnie Tapp, US Army Corps of Engineers, CESAJ-PD-ES, P.O. Box 4970, Jacksonville, FL 32232-0019 (904-791-1690)

Ancil Taylor, Bean Dredging Corp., Box 61003, New Orleans, LA 70161-1003 (504-286-8700)

Nancy Thompson, Sea Turtle Coordinator, National Marine Fisheries Service, 75 Virginia Beach Dr.,Miami, FL 33149 (305-361-4276)

Lim Villianos,* US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199 (601-634-2070)

J. Ross Wilcox, Florida Power & Light Company, Environmental Affairs Dept., P.O. Box 14000, Juno Beach, FL 33408 (407-694-3623)

---

* Registered but unable to attend.

Tom Williams, 116 N. 4th St., Fernandina Beach, FL 32034 (904-277-3097)

Ross Witham, 1457 N.W. Lake Pt., Stuart, FL 34994 (407-692-1469)

Tom Yourk, US Army Corps of Engineers, Savannah District, P.O. Box 889, Savannah, GA 31402 (912-944-5051)

Robert C. Ziobro, National Marine Fisheries Service, Protected Species Mgmt. Div., 1825 Connecticut Ave., Suite 805, North West Washington, DC 20235 (202-673-5348)

AGENDA
NATIONAL WORKSHOP ON METHODS TO MINIMIZE
DREDGING IMPACTS ON SEA TURTLES

11-12 May 1988
Sea Turtle Inn
Jacksonville, Florida

11 May 1988

0800 Welcome - James D. Hilton (CE Jacksonville District)

0810 Workshop Introduction--Vincent Montante (Dredging Division, Corps of Engineers, Washington, DC)

0820 Workshop Objectives--David A. Nelson (US Army Engineer Waterways Experiment Station, Vicksburg, MS)

0830 An Overview of the Endangered Species Act or 1973, As Amended, and Its Application to Endangered Species/Dredging Conflicts in Port Canaveral, FL--Tyrrell A. Henwood (National Marine Fisheries Service, St. Petersburg, FL)

0900 Implementation of Endangered Species Act: Canaveral Navigation Channel Dredging, a Case History--Jonathan D. Moulding (US Army Engineer District, Jacksonville, Jacksonville, FL)

0930 Break

Technical Session I: Tyrrell A. Henwood, Chairman

1000 Turtles in Cape Canaveral: What, When, and Where--Nancy B. Thompson (National Marine Fisheries Service, Miami, FL)

1030 The Sea Turtles of the King's Bay Area and the Endangered Species Observer Program Associated with Construction Dredging of the St. Marys Entrance Ship Channel--James I. Richardson (Institute of Ecology, Athens, GA)

1100 Resolution of Dredging Impacts on Sea Turtles by the Galveston District--Robert Hauch (US Army Engineer District, Galveston, Galveston, TX)

1120 Overview of Sea Turtle Entrapment Studies at a Power Plant--J. Ross Wilcox (Florida Power & Light Company, Juno Beach, FL)

1150 Question and Answer Period

1200 Lunch

Technical Session II: James D. Hilton, Chairman

1300 Canaveral Harbor Entrance Channel Operational Measures To Protect Sea Turtles--Stephen A. Berry (US Army Engineer District, Jacksonville, Jacksonville, FL)

1330 Introduction to Alternative Dredging Methods--Michael R. Palermo (US Army Engineer Waterways Experiment Station, Vicksburg, MS)

1400 Dredging Industry Representatives (Capabilities and Restrictions)
Clamshell Dredges--Brian Lindholm (Great Lakes Dredging, Staten Island, NY)

Hydraulic Cutterhead Pipeline Dredging--Leon Hrabovsky (T. L. James & Co., Kenner, LA)

The Hopper Dredge--Ancil S. Taylor (Bean Dredging Corp., New Orleans, LA)

Discussion Sessions

1530 Break and Group Assignments

Group Facilitators:

Dena Dickerson (US Army Engineer Waterways Experiment Station, Vicksburg, MS)

Michael R. Palermo (US Army Engineer Waterways Experiment Station, Vicksburg, MS)

James I. Richardson (Institute of Ecology, Athens, GA)

1540 Group Meetings

1630 Adjourn

12 May 1988

0830 Introduction/Announcements

Technical Session III: Ross Witham, Chairman

0840 Sea Turtle Hibernation in the Cape Canaveral Ship Channel--Peter Lutz (University of Miami, Miami, FL)

0910 Radio Tagging of Sea Turtles--Edward Standora (State University College, Buffalo, NY)

0940 Current Sea Turtle Surveys at Cape Canaveral Ship Channel--Alan Bolten (University of Florida, Gainesville, FL)

1000 Break

Discussion Sessions

1020 Group Meetings

1200 Lunch

1320 Group Meetings

1520 Break

1550 Summary of Group Meetings by Group Facilitators

1630 Summary Remarks

1640 Adjourn

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
horsepower (550 foot-pounds (force) per second)	745.6999	watts
inches	2.54	centimetres
knots (international)	0.5144444	metres per second
miles (US statute)	1.609347	kilometres
pound (mass)	0.4535924	kilograms
pounds (force) per square inch	6.894757	kilopascals
square inches	6.4516	square centimetres
tons (2,000 pounds, mass)	907.1847	kilograms

PROCEEDINGS OF THE NATIONAL WORKSHOP ON METHODS TO MINIMIZE DREDGING IMPACTS ON SEA TURTLES, 11 AND 12 MAY 1988, JACKSONVILLE, FLORIDA

BACKGROUND AND INTENT

The US Army Corps of Engineers (CE) sponsored the "National Workshop on Methods to Minimize Dredging Impacts on Sea Turtles" on 11-12 May 1988, Jacksonville, FL, to focus on national concerns about dredging effects on sea turtles. The workshop addressed requirements of Section 7(b)(4) of the Endangered Species Act (ESA), which states that when a proposed agency action may incidentally take individuals of listed species status, the National Marine Fisheries Service (NMFS) will issue a statement which specifies the impact of such incidental taking and that reasonable and prudent measures will be provided to minimize such impacts.

The primary objective of the workshop was to identify engineering and/or biological methods that would prevent mortality and harm to sea turtles by dredges. The specific areas of concern were the effects from maintenance dredging operations conducted annually for the US Navy in the Cape Canaveral and King's Bay ship channels. The workshop addressed both biological and engineering aspects of the subject through formal presentations, group discussions, and subgroup sessions. Participants included 71 representatives from the CE, NMFS, US Fish and Wildlife Service (USFWS), US Navy, dredging industry, universities, and other related support agencies and organizations.

OPENING REMARKS

WORKSHOP INTRODUCTION

by

Mr. Vincent Montante*

The passage of the National Environmental Policy Act in 1969 and subsequent laws and regulations which govern the dredging process have resulted in a renewed effort on the part of the CE to enhance the environment.

The Corps is proud of the progress it has made over the years in this regard and of the improved relationships that we have helped foster with other environmental groups, such as the NMFS, the Environmental Protection Agency (EPA), the USFWS, and the Environmental Research Community.

The success of the first interagency workshop on the beneficial uses of dredged material held in Pensacola, FL, in 1986 and of subsequent workshops in Baltimore, MD, and St. Paul, MN, is a testimony to the strides that we have made in the environmental arena.

Each workshop provided a forum for over 200 individuals from Federal, State, and local government agencies in addition to bringing many private environmental groups together to discuss in a positive and constructive way how the uncontaminated material dredged from our Nation's waterways can be put to beneficial use.

I am hopeful that this workshop is as successful in helping to decrease the mortality of sea turtles by dredging equipment. As you know, the mortality rate of sea turtles has decreased significantly since 1980 as a result of efforts by the Sea Turtle/Dredging Task Force. Through testing and implementing various protective measures and expanding sea turtle population studies, the task force has made great strides in decreasing sea turtle mortalities.

Trawling during each month of the year was performed, and concentrations of sea turtles by species were documented for various segments of the Canaveral channel. Trawling ahead of the dredge to remove sea turtles was tried, but proved to be impractical since the trawler had to move at a slower speed than the dredge.

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* Dredging Division, US Army Corps of Engineers, Washington, DC.

Additional efforts such as sonic pingers, electroshock, and welding plows on the dragheads of the dredge were also tried. Unfortunately, none proved effective in preventing sea turtle mortality.

At this time, prudent measures have been adopted and are required on all Corps hopper dredge contracts at Canaveral to include the use of California-style dragheads, restricting the size of openings in the draghead to 120 sq in.,* screening water intakes on the dragarms and dragheads, and screening hopper bins with openings no larger than 3 in. In addition, sea turtle observers must be onboard the dredge while dredging and disposal operations are ongoing; suction pumps must be turned off when the dragheads are not in bottom sediment; and hopper dredging is restricted to the months of September through November when sea turtles are thought to be not as abundant in the channel area.

Because the task force members were not aware of any other measures which could be used to further reduce the mortality of sea turtles or increase the monitoring of sea turtle parts in the hopper bins, it was felt that possibly other individuals may have proven or unproven methods to reduce sea turtle mortalities and/or increase the monitoring of hopper bins for sea turtle parts.

Thus, this workshop will bring together individuals involved in all aspects of dredging and individuals knowledgable in sea turtles to help develop new methods to reduce sea turtle mortality resulting from dredging operations.

If mortalities cannot be eliminated, then we must explore ways to improve the monitoring in hopper bins and documentation of actual numbers of mortalities.

Obviously, any methods we develop will be used on a national basis by the Corps in its dredging program if at all possible.

And one last remark: Threatened endangered sea turtles and all threatened endangered species are protected by the Federal Endangered Species Act. The NMFS has a mandate to support and enforce that law. Likewise, the Corps has a mandate to maintain the Nation's waterways so that our economy will continue to flourish. I do not see these as competing mandates. The

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 12.

Corps, the dredging industry, and the NMFS have a responsibility and an obligation to work together to protect endangered species.

I would like us to enter the workshop with that thought in mind, and I am confident that together we can achieve significant and positive results in the next couple of days.

AN OVERVIEW OF THE ENDANGERED SPECIES ACT OF 1973, AS AMENDED, AND ITS APPLICATION TO ENDANGERED SPECIES/DREDGING CONFLICTS IN PORT CANAVERAL, FLORIDA

by

Tyrrell A. Henwood*

Introduction

The Port Canaveral ship channel (Figure 1) allows navigation from offshore through a man-made inlet to a protected harbor. The original channel linking the Intracoastal Waterway of the Indian River, through the land dunes of the Cape, to the deep waters of the Atlantic Ocean was completed in 1952. The entrance channel was deepened in 1956 from its original depth of 27 to 36 ft, and to 37 ft in 1961. The channel was further lengthened (distance from the bend to the outer end was increased from 12,500 to 29,000 ft) and deepened (depth was increased to 43 to 44 ft) during 1974 to 1976 dredging and is presently maintained at this length and depth.

Shoaling and sediment depositions within the channel occur as a result of local sediment transport patterns and wave actions, but can fluctuate greatly due to occasional storms. To sustain depth specifications necessary for navigation by the US Navy, the CE has been tasked to annually remove these materials. Historically, a hopper dredge has been used for the majority of dredging in the entrance channel.

While maintenance dredging is required for most existing navigational channels in the southeastern United States, the Canaveral channel is unique in that dredging impacts the largest known aggregation of subadult loggerhead turtles in the world. Additionally, Kemp's ridley, green, and adult loggerhead turtles are known to inhabit the Canaveral channel. Consequently, the NMFS issued a "jeopardy" Biological Opinion (BO) for Canaveral dredging in 1984 and has closely monitored all subsequent dredging activities.

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* National Marine Fisheries Service, Southeast Region, St. Petersburg, FL.

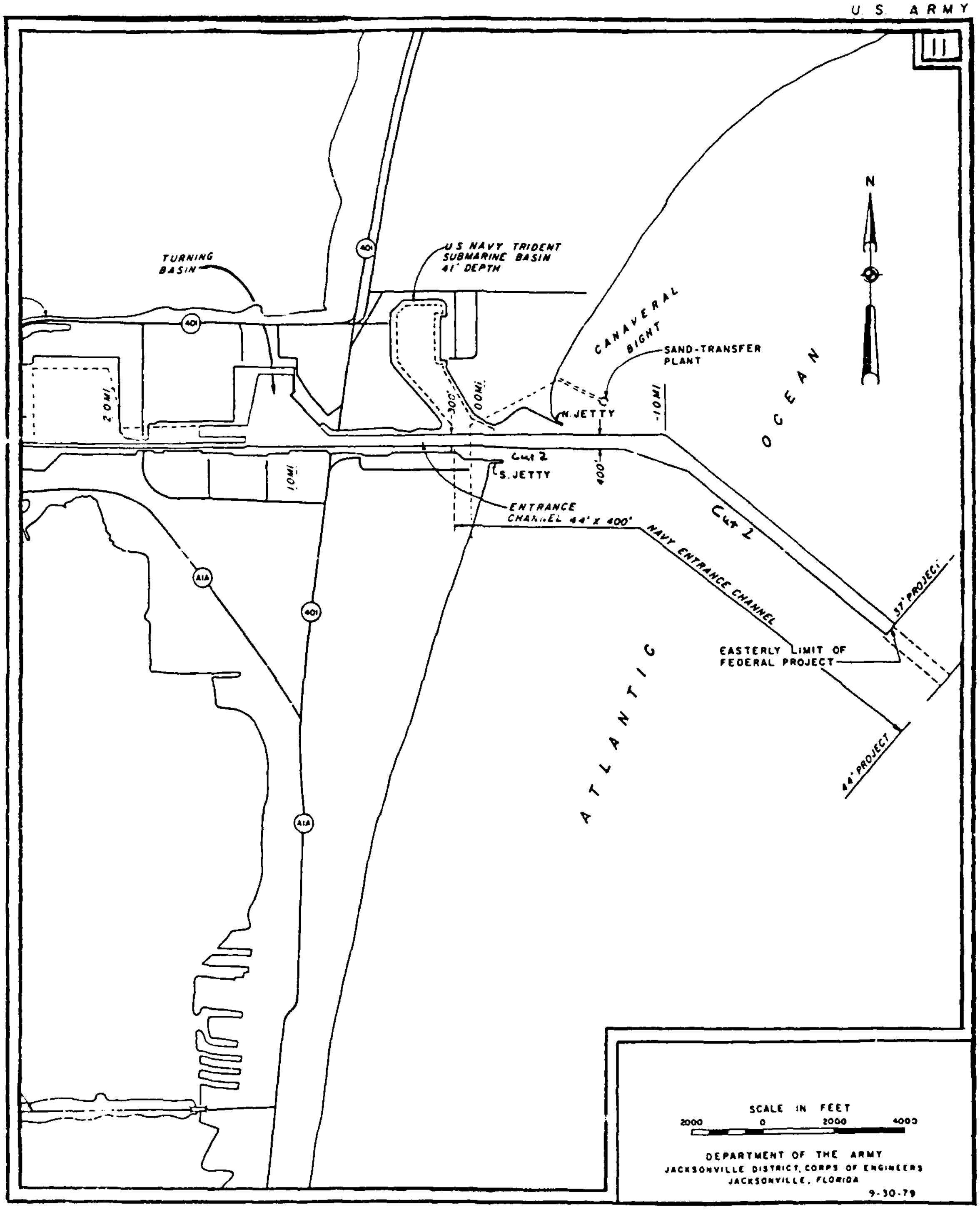

Figure 1. Cape Canaveral, Florida

After years of ESA Section 7 consultations with the CE on Canaveral channel dredging, it seems that the same questions and myths continue to creep into all discussions. Here, I will attempt to describe the objectives of the ESA, the Section 7 consultation process, the possible outcomes of consultations, the NMFS and CE responsibilities during consultation, the Incidental Take Statement, and exceptions to the requirements of the ESA (for example, the National Defense exemption).

Endangered Species Act of 1973, As Amended

The purposes ot the ESA are "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth." The Act states that it is the policy of Congress "that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act."

This Act reflects a national philosophy that endangered and threatened species must be protected and that government departments and agencies should take all possible precautions to assure that their activities do not negatively impact listed species. This legislation reflects the will of the majority of American citizens, and although some may disagree with the provisions of the Act, it is a law to which Federal agencies must adhere.

In the case of Cape Canaveral channel dredging, the evidence indicates that turtles are killed by hopper dredges. Therefore, to be in compliance with the spirit of the Act, the CE must consider all alternatives or measures which will conserve endangered and threatened species by minimizing or eliminating these mortalities.

Endangered Species Act Section 7 Consultations

The NMFS is responsible for administering the ESA for all Federal actions which may impact endangered and threatened species at sea. Section 7 (a)(2) of the ESA requires Federal agencies, in consultation with and with the assistance of the Secretary, to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of the habitat of such species which has been designated as critical ("critical habitat"). The NMFS performs an advisory function under Section 7 by consulting with other Federal agencies to identify and help resolve conflicts between the actions of Federal agencies and listed species, as well as their critical habitat.

The consultation process is relatively simple. A Federal agency requests from NMFS a list of threatened and endangered species which might occur in the project area. Upon receipt of this list, the agency prepares a Biological Assessment (BA) which describes the proposed activity and identifies any endangered or threatened species which are likely to be affected by this activity. In the BA, the Federal agency determines either that the proposed activity will not impact listed species or that listed species may be impacted. If the agency determines that the activity will not affect listed species and NMFS concurs in writing, no formal consultation is necessary. If the agency determines that the activity may affect listed species, additional consultation is necessary.

In formal Section 7 consultations, NMFS must formulate a BO as to whether or not the activity (with its cumulative effects) "is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat" 50 Code of Federal Regulations (CFR) Section 402.14 (g)(4)(1986); see also, 50 CFR Section 402.14 (h)(3)(1986). If a no-jeopardy opinion is issued, the activity is allowed to proceed despite adverse effects to listed species if the agency adheres to suggested reasonable and prudent measures. If a jeopardy opinion is issued and reasonable and prudent alternatives to avoid jeopardy are provided, the activity can continue if the agency implements these alternatives. If there are no reasonable and prudent alternatives to the proposed action and the Federal agency determines that the proposed action cannot comply with Section 7 (a)(2), the action cannot proceed without an exemption.

Prior to the 1984 BO on dredging in the Canaveral channel, NMFS had concluded that dredging did not constitute a "jeopardy" to the continued existence of endangered and threatened species, but that the activity might impact listed species. The NMFS determined that the resultant incidental take to listed species did not violate Section 7 (a)(2) and provided an "Incidental

Take Statement" including reasonable and prudent measures intended to minimize the level of incidental taking.

The 1984 "jeopardy" opinion, which reversed our previous "no-jeopardy" opinions, was based on the NMFS belief that populations of green turtles in Florida and the Kemp's ridley could not withstand an avoidable loss of individuals if the species were to remain viable. At this time, NMFS identified reasonable and prudent alternatives which could be implemented by the CE and would allow the dredging to be conducted. Since that time, the CE has incorporated these alternatives in its dredging operations.

The NMFS 1987 "no-jeopardy" BO was based on our determination that the activity would not jeopardize listed species if a clamshell dredge were used. This method of dredging has been demonstrated to reduce or eliminate the take of sea turtles. The CE has argued that the clamshell dredge is inefficient and cannot be used for dredging the outer reaches of the channel. For the 1988 dredging period, the CE has proposed the use of two hopper dredges; the NMFS believes this method of dredging will result in substantial mortalities to sea turtles and could jeopardize the continued existence of Florida green and Kemp's ridley turtles.

Jeopardy Versus No Jeopardy--Reasonable and Prudent Alternatives Versus Measures

With respect to the Canaveral dredge/endangered species conflict, the jeopardy opinion means that the CE must implement reasonable and prudent alternatives as recommended by NMFS to avoid jeopardizing the continued existence of endangered or threatened species. The reasonable and prudent alternatives include actions that are economically and technologically feasible, that are consistent with the intended purpose of the action, and that the Federal agency and applicant have authority to implement. If the CE does not or cannot implement these recommended alternatives, the action cannot go forward without an exemption.

The no-jeopardy opinion with an Incidental Take Statement obligates the CE to implement reasonable and prudent measures as recommended by NMFS in order to be in compliance with the ESA. However, the measures are limited to actions that minimize impacts and do not alter the basic design, location, duration, or timing of the actions.

Incidental Take Statement

The Incidental Take Statement is provided with biological opinions when the activity may incidentally take individuals of a listed species but not so many as to jeopardize their continued existence. If the action proceeds in compliance with the terms and conditions of the Incidental Take Statement, then any resulting incidental takings are exempt from the prohibitions of Section 4 (d) or 9 of the Act. The BO, plus the Incidental Take Statement, operates as an exemption under Section 7 (o)(2) of the Act. However, this exemption is limited to action taken by the Federal agency or applicant that complies with the terms and conditions specified in the Incidental Take Statement. Actions that do not comply with the specified measures remain subject to the prohibitions against takings that are contained in Section 9.

The Incidental Take Statement includes a discussion of the impacts (amount or extent) of the anticipated incidental take and a discussion of the measures that are necessary and appropriate to reduce or minimize the impacts. The allowable incidental take level is generally the anticipated (probable) level.

Many people misinterpret the Incidental Take Statement as designating an acceptable level of take during a given activity. The NMFS does not condone the take of any threatened or endangered species. The Incidental Take Statement is simply a means of exempting the CE and its contractors from prosecution if an endangered or threatened species is taken, assuming that all possible steps to minimize the impacts of CE activities to listed species have been implemented.

The point should be made that the Incidental Take Statement protects the contractors (i.e. the dredge companies) as long as they are in compliance with the reasonable and prudent measures or alternatives. Without the Section 7 consultation and Incidental Take Statement, any incidental take would be subject to prosecution.

Exemptions

Some persons are under the impression that an NMFS "jeopardy" BO and associated reasonable and prudent alternatives can be easily overturned by invoking the National Security exemption as described in Section 7 (j) of the

Act. This exemption states, "Notwithstanding any other provision of this Act, the Committee shall grant an exemption for any agency action if the Secretary of Defense finds that such exemption is necessary for reasons of national security." While this might be used to circumvent the ESA Section 7 process, it is a great deal more complicated than it may appear. First, the Endangered Species Committee, which must review this application for exemption, is made up of the following persons:

a. Secretary of Agriculture.

b. Secretary of the Army.

c. Chairman of the Council of Economic Advisors.

d. Administrator of EPA.

e. Secretary of the Interior.

f. Administrator of the National Oceanic and Atmospheric Administration.

g. A Presidential appointee from the affected state.

To my knowledge, this Committee has never met.

Second, before the Endangered Species Committee sees an application for exemption, a review board must consider the application and submit a report to the Committee. This three-member review board consists of the following:

a. One person appointed by the Secretary of Commerce.

b. One member appointed by the President.

c. An administrative law judge.

The first criterion which the board considers is whether the agency carried out its consultation responsibilities in good faith and made a reasonable and responsible effort to develop and fairly consider modifications or reasonable and prudent alternatives.

Third, it is questionable whether the US Navy would chose to invoke this provision for dredging the Canaveral channel. They would have to go through this process on an annual basis (the exemption would apply only to an individual case), would probably receive a great deal of negative publicity, would have trouble justifying their use of this exemption when reasonable and prudent alternatives exist, and might have trouble convincing the Committee that delays in dredging the Canaveral channel constitute a threat to national security.

Exemptions were designed for cases when a jeopardy opinion is issued and there are no reasonable and prudent alternatives available. The purpose of exemptions is not to provide a means for agencies to circumvent the ESA, especially when reasonable and prudent alternatives exist. The US Navy is obligated to conform to the provisions of the Act just like all other Federal departments and agencies.

Conclusions

Having reviewed the ESA and the Section 7 process, let us examine the facts. First, the CE has the responsibility of maintaining the Canaveral channel; to meet these obligations, annual dredging is necessary. Second, the most efficient means of accomplishing this task at the present time is by using a hopper dredge. Third, large numbers of threatened and endangered sea turtles occur in this channel, and unknown numbers are killed by hopper dredges during each dredging episode. Fourth, the ESA requires Federal agencies to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species.

Considering these facts, it is obvious that this is a difficult problem to resolve. The CE is required to maintain the channel at specified depths and is expected to conduct this dredging in the most efficient and cost-effective manner. However, they are also required under the ESA to ensure that this dredging does not jeopardize endangered and threatened species. This places the CE in somewhat of a dilemma, because at least in Canaveral, while meeting its obligations to maintain the channel depth in a cost-effective manner (i.e. the hopper dredge), the Corps is unable to meet its endangered species obligations because it is using a dredge which is known to kill sea turtles. If, on the other hand, the Corps uses a clamshell dredge which satisfies the ESA requirements and also allows it to dredge the channel, the operation is less efficient and cost-effective.

From the NMFS perspective, cost effectiveness is not a major consideration in determining which dredge will be used. If a slightly less efficient dredge which does not take sea turtles is available, the NMFS believes that the CE should use this option to meet its ESA obligations. Annual confrontations on dredging in Cape Canaveral will continue until a satisfactory means of reducing or eliminating turtle mortalities from dredging is achieved. The NMFS considers the use of hopper dredges in the Canaveral channel to be an unacceptable and avoidable source of sea turtle mortalities. This determination applies to both short- and long-term cumulative impacts of dredging to sea turtle populations.

While the Canaveral channel is unique in the number of sea turtles which occur, the NMFS believes that many other channel dredging projects may also be impacting sea turtles. For this reason, we urge other CE Districts and the dredging industry to give serious consideration to this problem. If the NMFS receives information that turtles are being taken elsewhere, we will take action and request reinitiation of consultation on the basis of new information. Potentially, similar conflicts could occur in any number of channel dredging projects.

The NMFS is optimistic that this workshop will result in some positive ideas on new dredge types, modifications to existing dredges, or new dredging techniques which will eliminate turtle mortalities. If an acceptable alternative to the present hopper dredge can be found, the NMFS will recommend that this alternative be used in all areas where sea turtles are known to occur. This statement should be of particular significance to industry because it could have a bearing on competitive bidding for contracts. The NMFS can and will include in our Incidental Take Statements a requirement that only certain types of dredges may be used in areas where turtles are known to occur, if such dredges are proven to effectively reduce or eliminate sea turtle mortalities and can be operated in an efficient and cost-effective manner.

IMPLEMENTATION OF THE ENDANGERED SPECIES ACT, CANAVERAL NAVIGATION CHANNEL DREDGING, A CASE HISTORY

By

Jonathan D. Moulding*

The Jacksonville District's experience in 1980 with conflicts between maintenance dredging of the Canaveral navigation channel and sea turtles is used as an example of the coordination procedure that is involved for compliance with the ESA.

The Canaveral navigation channel dates back to the early 1950's. Unlike most channels in Florida, it was constructed through the barrier island where there had never been a natural inlet. There has been some dredging, either further deepening or maintenance dredging, in the channel almost every year since the project was begun. No instances of sea turtle injury or mortality in conjunction with dredging had ever been reported. During the two (unusually cold) winters prior to the scheduled 1980 maintenance dredging, the presence of large numbers of loggerhead sea turtles in the channel was brought to the attention of the scientific community by shrimp fishermen who had incidentally trawled-up many turtles in a torpid condition.

Subsequently, the NMFS, which has responsibility for sea turtles in the water under the ESA, raised the question of possible adverse dredging impacts on turtles in conjunction with the 1980 dredging cycle. Given the history of the project, no one could predict with any confidence if a hydraulic hopper dredge would take a turtle, particularly since the dredging was scheduled for the summer months when the turtles would not be torpid. During formal consultation under provisions of Section 7 of the Act, the CE and NMFS agreed that if dredge take was documented, a turtle rescue plan would be implemented to relocate turtles from the path of the dredge. Under these conditions, the NMFS determined that the project would not jeopardize the continued existence of the species. This determination allowed the dredging to proceed without being in conflict with the Act.

Shortly after dredging began in July 1980, the biologists employed as observers on the dredge documented that turtles were indeed being killed by the dredge. According to the prearranged rescue plan, a local shrimp

* Environmental Resource Branch, US Army Engineer District, Jacksonville, Jacksonville, FL.

fisherman was then contracted to trawl ahead of the dredge to clear the channel of turtles and relocate them down the coast to safety. However, it soon became apparent that this was not fully successful. It was not safe for the trawler to work directly in front of the moving dredge because the nets would often bog down when they encountered large clay balls created by the dredging. This would spin the trawler around and subject it to a potential collision with the dredge. Consequently, the trawling was conducted well away from the dredge in areas usually where the bottom had not yet been disturbed. There were unexpectedly large numbers of turtles coming into the channel, particularly later in the year, such that it was not possible to stay ahead of the population. Also, the turtles tended to come back into the channel after being released 5 miles away.

The dredge continued to take turtles throughout the operation, despite all efforts. Figures 1 and 2 show the trends in dredge take, turtles captured and relocated, and turtles recaptured after returning to the channel. The continued loss of turtles resulted in a conflict with Section 9 of the Act, which, independent of the jeopardy provision, prohibits the taking of individuals of protected species even if it is unavoidable incidental take from an operation that is otherwise in accord with the Act. This conflict was not resolved until the Act was amended in 1982 to allow, among other things, a level of incidental take to be factored into the jeopardy determination. Measures to provide increased protection to sea turtles have evolved and improved during consultations on maintenance dredging since 1980, but as of this writing, it is not yet possible to eliminate all mortality.

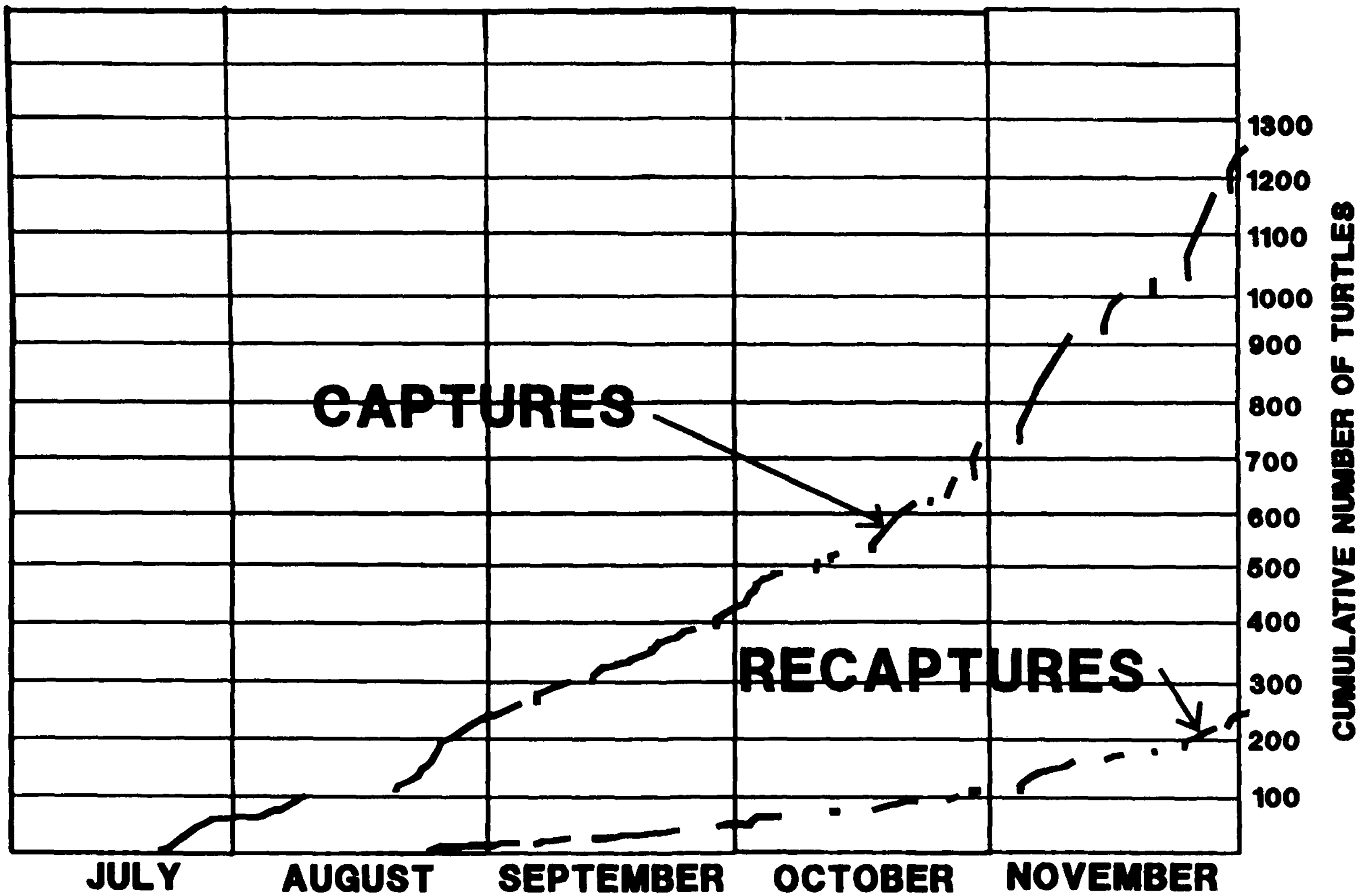

Figure 1. Canaveral channel turtle catch during rescue trawling operation, 1980

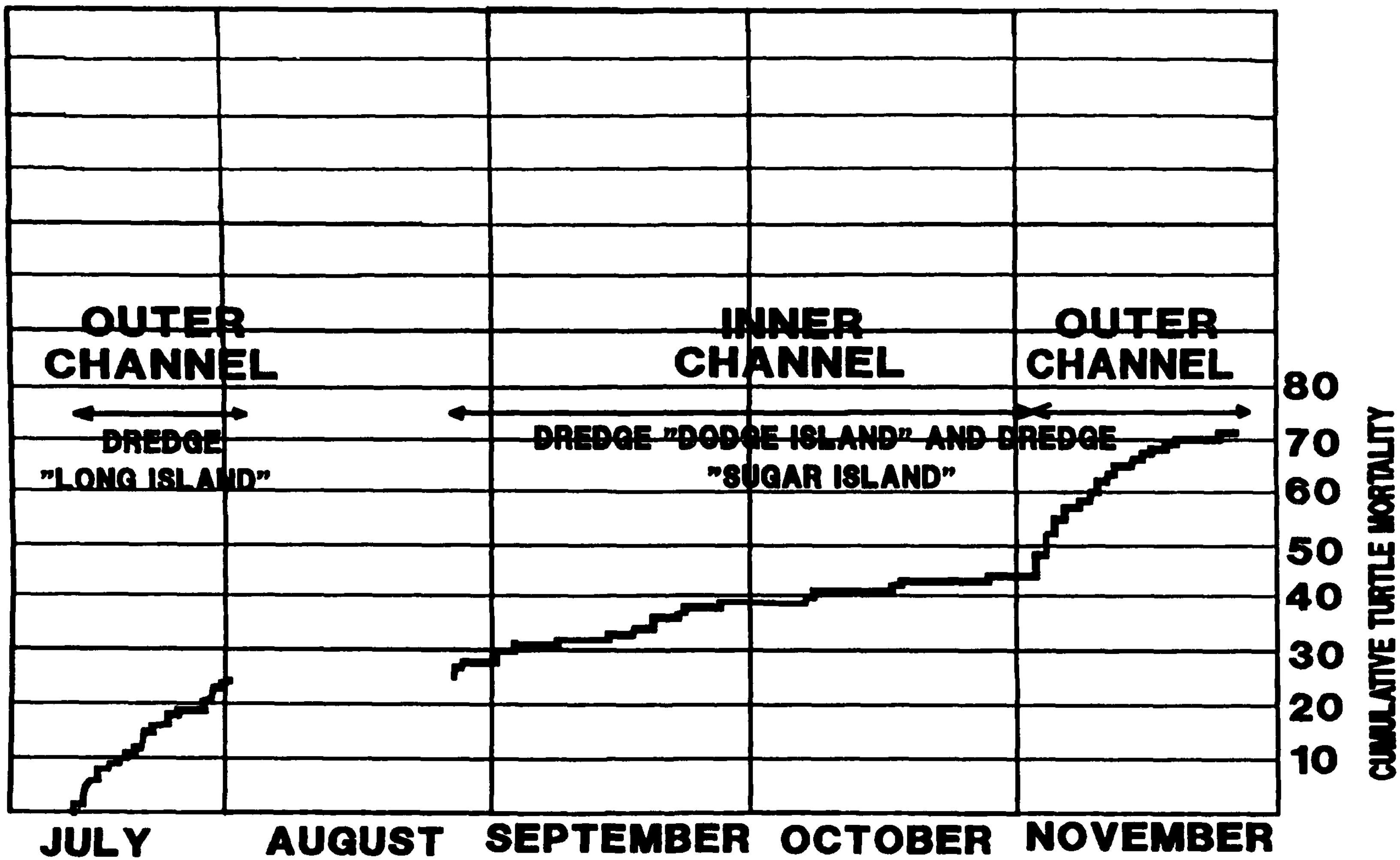

Figure 2. Incidental turtle loss, Canaveral channel maintenance dredging, 1980

TECHNICAL SESSION I

Tyrrell A. Henwood,* Chairman

TURTLES IN CAPE CANAVERAL: WHAT, WHEN, AND WHERE

by

Nancy B. Thompson**

Since 1978, the Southeast Fisheries Center has been conducting research on marine turtles in the Cape Canaveral area, including the ship channel proper. During these efforts, four species of marine turtles have been observed. The loggerhead turtle is the most abundant turtle in US waters and is proportionally the most abundant turtle in the Canaveral area. During pelagic aerial surveys conducted seasonally from 1982 to 1984, 2,346 sightings of loggerhead and 128 sightings of leatherback turtles were recorded. Loggerhead turtles were most abundant during the spring and summer; leatherback turtles were almost exclusively sighted during the summer. Loggerhead turtles were found uniformly from the coastline out to about the 40-m isobath. There is somewhat of a seasonal shift out from the coastline in the fall and winter, which may be a result of warmer Gulf Stream boundary waters and distributions of prey. Leatherback turtles were observed over midshelf waters and tended to be clumped, likely reflecting the distribution of their primary prey, jellyfish. Vessel surveys conducted from 1978 through 1982 in the Cape Canaveral ship channel resulted in captures of loggerhead, Kemp's ridley, and green turtles. There was a strong seasonal effect for both loggerhead and Kemp's with the peak in capture rates occurring in the winter and early spring. This was also observed for the green turtle, but this species also demonstrated a secondary peak in the early summer. Most turtles that were captured were immature turtles. As expected with the advent of the nesting season, the appearance of mature turtles proportionally increased. Within the ship channel proper, turtles were distributed toward the center of

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* National Marine Fisheries Service, Southeast Region, St. Petersburg, FL.

** Sea Turtle Coordinator, National Marine Fisheries Service, Miami, FL.

the channel. The concentration of turtles in this area has resulted in our focusing efforts on describing the surface behavior of turtles using radio and satellite tagging, and for testing and evaluating old and new turtle excluder devices (TEDs). We will continue testing new TED designs in the late winter and early spring.

THE SEA TURTLES OF THE KING'S BAY AREA AND THE ENDANGERED SPECIES OBSERVER PROGRAM ASSOCIATED WITH CONSTRUCTION DREDGING OF THE ST. MARYS ENTRANCE SHIP CHANNEL

by

James I. Richardson*

Introduction

The St. Marys Entrance ship channel (Figure 1) begins some 10 miles seaward of Amelia Island and runs northwest and west to the entrance of Cumberland Sound separating Cumberland Island to the north and Amelia Island to the south. A dredged shipping channel, protected by 3 miles of stone jetties on either side of its western entrance, has been present for many years to serve the needs of the Port of Fernandina and the town of St. Marys. However, additional depth was needed to permit access by the Trident submarines to the King's Bay Naval Base. Construction dredging for this channel was initiated in July of 1988 (and planned to be completed in July of 1989) by Great Lakes Dock and Dredge Company and its subcontractor, Bean Dredging Company, under the supervision of the Jacksonville CE District. The frequency and individual vessel tonnage of ship traffic moving through the St. Marys Entrance is expected to increase substantially with completion of the submarine base and continued expansion of Fernandina's containerized cargo port facility.

The Endangered Species Observer Program at St. Marys evolved through consultation between the NMFS and the CE, as mandated by the ESA of 1973. Species of concern included the short-nosed sturgeon, manatee, right whale, and four species of sea turtles frequenting the area. We will consider only the sea turtles in this presentation.

Geographic Region

The St. Marys Entrance is located within the Georgia Bight, a semienclosed body of water which extends from Cape Fear, North Carolina, to Cape Canaveral, Florida. The Georgia Bight is well-known to scientists for

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* Institute of Ecology, University of Georgia, Athens, GA.

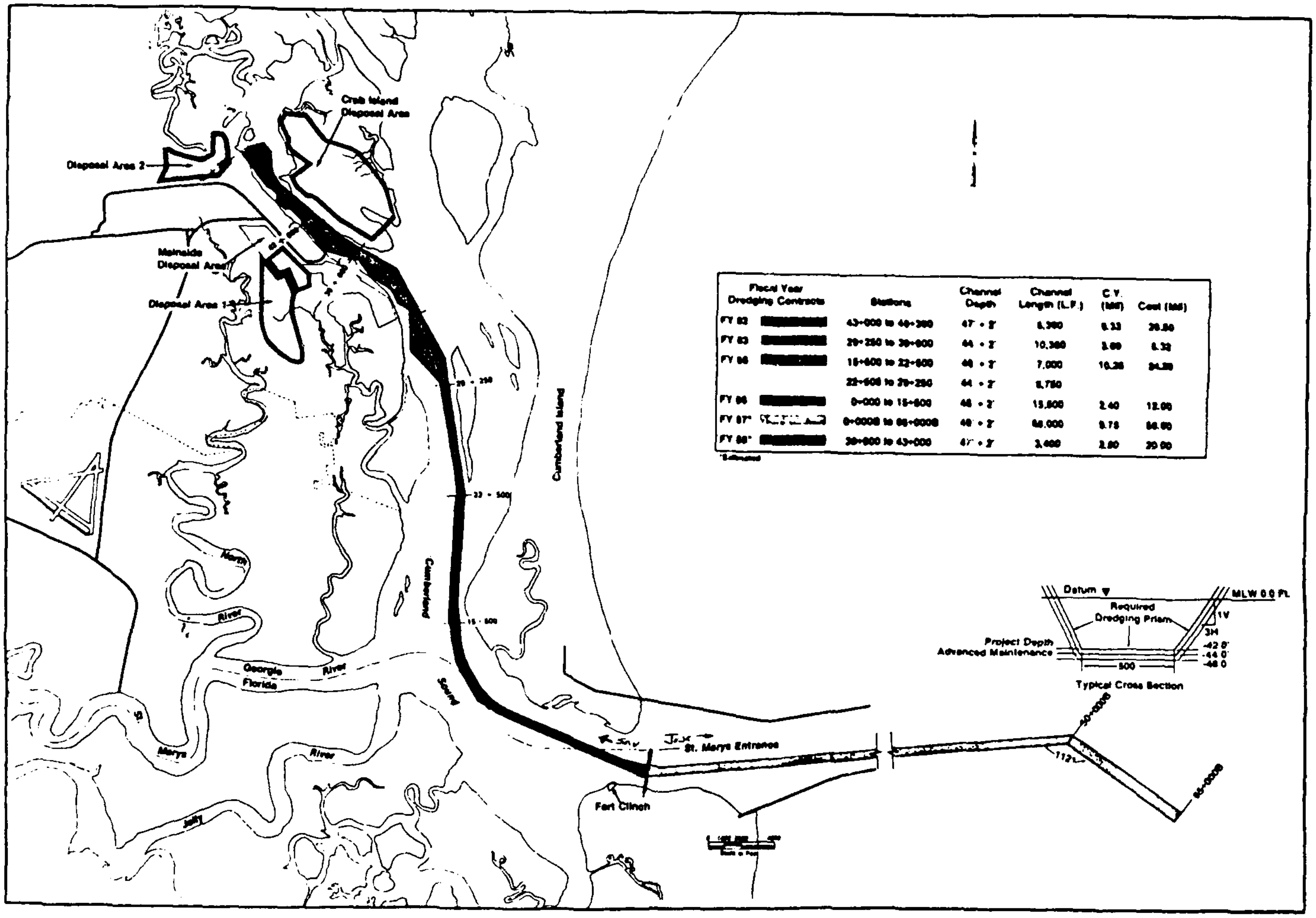

Figure 1. St. Marys Entrance ship channel, Kings Bay, Georgia

its unique oceanographic characteristics. These characteristics become most pronounced towards the regional center that corresponds to the Georgia coast and includes the St. Marys Entrance. For instance, tidal amplitude is greater here than at any other point along the southeastern coast, which accounts for the development of extensive salt marshes behind the barrier islands. The marshes, estuaries, and nearshore waters form elements of a dynamic marine system linked by the ebb and flow of the tides. The Gulf Stream is located approximately 60 miles seaward of the St. Marys Entrance, as opposed to 10 miles seaward of the Canaveral ship channel. The entire area from the coastal islands to the Gulf Stream is a vast, shallow marine shelf averaging 30 to 60 ft in depth.

The coast of the Georgia Bight consists of barrier islands along most of its length. The islands are highly mobile, retreating and advancing according to changes in sea level. For the past 10,000 years, the islands have been retreating in a westerly direction because of a rising sea level. On a more brief time scale, beaches erode and accrete substantial distances within a few years, estuarine entrances migrate north and south (except where jetties have fixed their position), and sandbars and channels appear and disappear within periods of a few months. Barrier islands do move, and they move all the time. It will be expensive and time-consuming to hold the desired position and depth of the St. Marys Entrance channel, as must be done for the submarine base.

The Georgia Bight is a rich organic system. The unusually high biological productivity of the system is driven and sustained by the pumping action of the tides. That is the reason that the fish and shrimp are found here in such large numbers, and that is why the turtles are also found here in such large numbers. We have talked about the dense concentrations of sea turtles within the restricted area of the Canaveral channel. Taken in its entirety, the Georgia Bight probably represents the principal foraging area for the loggerhead sea turtles of the western North Atlantic. We do not know exactly how many turtles there are in this nutrient rich area, but we do know from NMFS statistics that the highest numbers of sea turtle carcasses found on beaches occur within the Georgia Bight. This phenomenon is caused by the many shrimp trawlers harvesting the abundance of shellfish in the area (sea turtles drown when incidentally captured in trawl nets) and partly by the very large numbers of sea turtles in the area, also harvesting the abundance of marine life found there. There is no doubt that the Georgia Bight is a foraging habitat of great importance to turtles.

When you look at an aerial photograph of a barrier island within its estuarine setting, you will notice characteristic configurations of sandbars that form at either end of each island and extend as far as 3 miles offshore. Geologists from Sapelo Island Marine Institute have shown that these sandbar patterns are repeated at each estuarine entrance. We believe that endangered right whale cows seek refuge within these sandbar "archipelagoes" to deliver their calves each winter. We believe that sea turtles also take advantage of shoals and channels for food and shelter. If the sandbar configurations are altered, as has occurred with construction within the St. Marys Entrance, then we must assume that the behavior of the animals that live there may also change, perhaps not in an overly detrimental manner, but things will change. We need to understand how tightly linked are the physical and biological systems of the Georgia Bight as we struggle to mitigate the impacts of dredging on endangered sea turtles. We must seek to predict the response of natural systems as we implement these massive dredging operations that affect the flow of the tides and the configuration of the sea bottom.

Regional Biology of the Sea Turtles

Very little research has ever been done on the distribution and abundance of sea turtles in the St. Marys Entrance shipping channel. A winter trawling survey for the presence of sea turtles in the channel (NMFS investigation, March 1979) revealed no animals present. On the other hand, we have now completed 25 consecutive years of research on loggerhead sea turtles nesting on the islands of Jekyll, Little Cumberland, and Cumberland adjacent to the St. Marys Entrance. The density of nesting on these Georgia islands is far less than is found on the Melbourne beaches south of Cape Canaveral, and it does not compare with the numbers of nesting turtles at Cape Romaine, South Carolina, but there are loggerheads nesting here and on nearly every barrier beach along the entire coast of the Georgia Bight from North Carolina to Florida.

My discussion of loggerhead sea turtle biology can best be followed with the help of Figure 2. Note that the life cycle is divided into terrestrial and pelagic phases, the former amounting to no more than a few brief moments

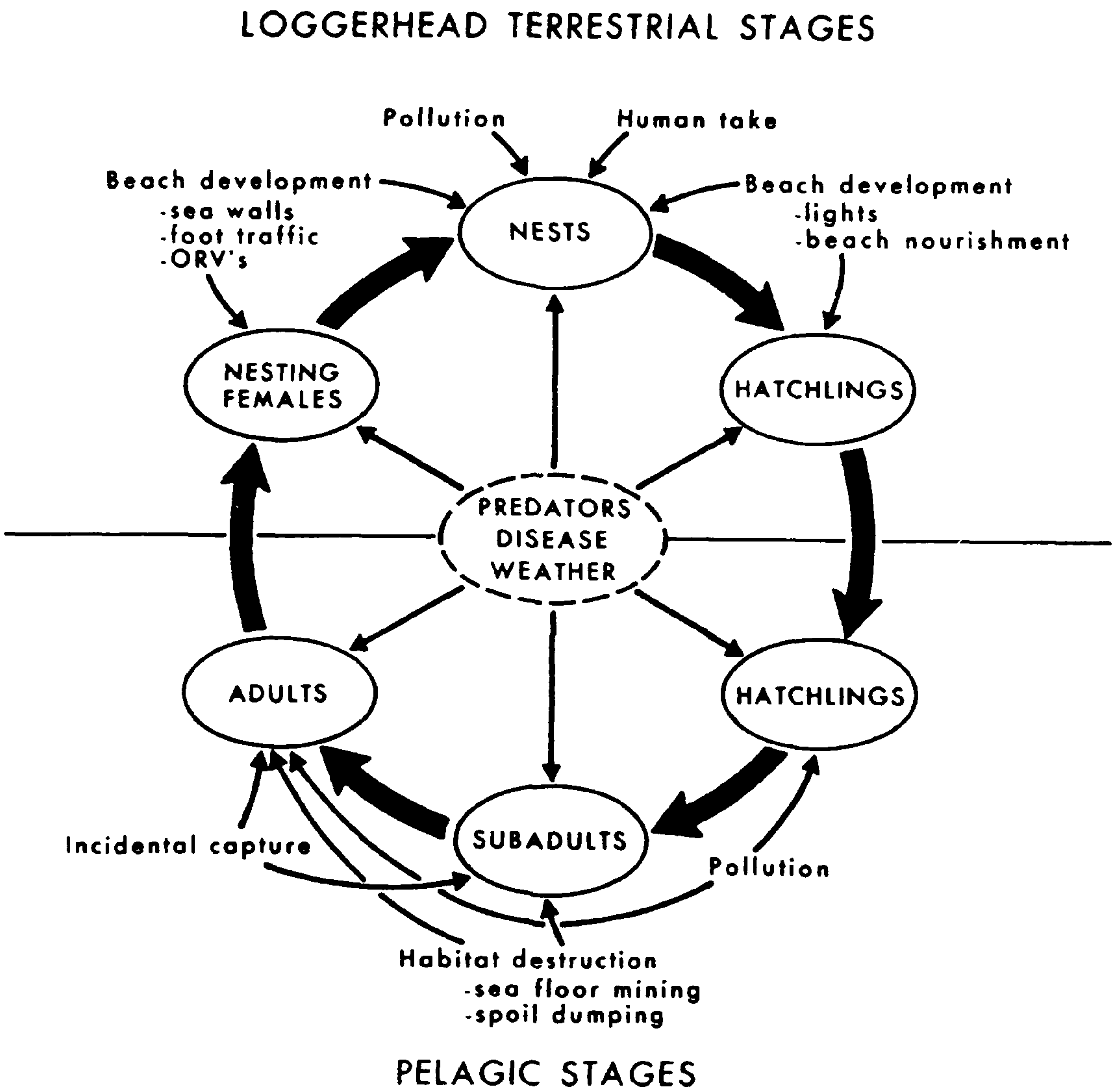

Figure 2. Sea turtle life cycle

in a lifetime that can exceed 50 years. We intend to focus at this workshop on the impacts of dredging on sea turtle survival, but note from Figure 2 that man impacts these animals at every stage of their life cycle. Efforts by the Corps to mitigate sea turtle losses are but one small part in the overall campaign to recover and manage these endangered animals.

Loggerheads arrive in nearshore waters to nest on our islands in April and May. Mating pairs are seen at this time, but the males appear to leave soon after their work is done. The adult females begin to nest in late May and continue through early August, at which time they also depart from near-shore waters of the Georgia Bight and are not seen again in our area until they return 2 or 3 years later to reinitiate the nesting act. Adult logger-heads that nest in Georgia are not found in the vicinity of the nesting beaches except when they are actively nesting. When not breeding or nesting, we believe the majority of these adults establish foraging territories well offshore on the Continental Shelf but still within the confines of the Georgia Bight.

The adult females crawl out on the beaches to nest at night. They do so on the beac.. outside the doors of this meeting facility, and they do so on both sides of the St. Marys Entrance channel on the beaches of Cumberland and Amelia Island. They come out of the water, locate an area of fresh dune sand slightly above the high-tide line, and excavate a nest chamber into which they deposit a clutch of approximately 120 eggs. They repeat this effort 4 or 5 times in a season, returning every 2 weeks to lay subsequent clutches of eggs, so that perhaps a single turtle will lay 600 eggs by the time she is finished with the nesting season. The entire time she spends on dry land during a nesting season is perhaps 5 hr. The cumulative time she spends in coastal waters near enough to be impacted by a dredge is perhaps no more than a week.

Many of you attending this meeting have witnessed the awesome spectacle of a giant sea turtle laying her eggs on a wild beach. If not, I encourage you to do so. The experience is really quite amazing. And while I am digressing for a moment, I would like to point out that sea turtles are severely deficient in mental acuity. I say this in good faith, because I like sea turtles, but you must realize that they do not have the intellectual capacity possessed by opossums and rats to deal with the challenges we present them. Sea turtles cannot adjust to the changes that we are causing to their environment; their survival is a responsibility that falls directly in our laps. I wish they did have a little more brain power, but they do not, so it is up to us to protect them.

Sixty days or so after a turtle's eggs have been deposited in the dune sand, the hatchlings emerge at night and rush without hesitation toward the water. Once they leave the beach, they are gone from our coastline for many years. We believe the hatchlings swim immediately for the Gulf Stream, a giant transportation system that will carry them on their way to the Sargasso Sea. The years that they are gone have been called the "lost years," a biological mystery that Dr. Archie Carr has pursued for most of his lifetime. It is his conclusion that the hatchlings gather during their early years in convergence lines of sargassum weed, which provides an extensive habitat between Africa and North America.

When we see our turtles again, they have become 50-lb juveniles with a carapace length of at least 20 in. They are the ones that represent 90 percent of the carcasses that are dead on the beaches around the St. Marys Entrance and throughout the Georgia Bight, 90 percent of what the shrimpers find in their nets while pursuing their trade, and probably fair to say 90 percent of the animals that we are dealing with when we talk about dredging and maintaining channels in the Georgia Bight. The juveniles arrive in April (usually) and leave in October (usually). They are here in the estuaries to gorge on shellfish during the summer months and to grow as fast as they can.

Nearly all of the young turtles in this area of South Carolina, Georgia, and northern Florida have to leave during the winter months because the water becomes too cold. Coastal water temperatures can drop to 9° C (48° F), generally much lower than the winter temperatures endured by sea turtles in the Canaveral area. Sea turtles evidently bury themselves quite frequently in sand or mud for extended periods of time, a phenomenon known as brumation (not too different from the hibernation behavior of mammals). However, at temperatures of 10° C and lower, the buried animals begin to accumulate gas, which causes them to tear loose from their moorings in the bottom sediments and float to the surface in a torpid condition. We have seen this phenomenon of "cold-stunning" in the Canaveral area of Florida after severe cold fronts have swept the area. When an occasional cold front of this magnitude chills the water, a hundred or more sea turtles may pop to the surface and have to be rescued. If sea turtles are lured into brumating within the depths of the newly deepened St. Marys Entrance channel, we will expect to witness cold-stunning episodes on a regular basis in our area.

Summarizing, loggerhead sea turtles in the vicinity of the St. Marys Entrance are with us for 2 months while the embryos are developing in the egg, for a few hours as the hatchlings emerge from the dune nest to rush to the sea and move offshore, for a period of about 7 months per year as foraging juveniles during the 10 to 30 years it takes them to reach maturity, and for a few months each nesting season when the adults move inshore from their offshore foraging areas to breed and lay their eggs on the beaches. If the turtles concentrate their numbers in the newly deepened St. Marys Entrance channel, as they now do in the Canaveral channel, then we will expect to see significant problems. If we are too far north of Canaveral, or if the tidal currents are too swift to make the channel attractive habitat, or if there are other reasons that we yet do not understand, then perhaps the turtles will not concentrate, and we shall consider ourselves lucky.

I have talked only about the loggerhead so far, because that is the most abundant turtle in the area, but we also have three other species of sea turtles that need to be considered: the green, the Kemp's ridley, and the leatherback. A fifth species, the hawksbill, is a tropical water turtle that has never been seen in the St. Marys area. The Kemp's ridley, which comes to us as a subadult, is the most endangered of all the sea turtle species in the world. Fortunately, we have not witnessed any mortality of this species as a result of the dredging activity in the St. Marys Entrance. We have a few juvenile green turtles, but we do not have the adults that nest along Florida's southern coast. We have had a single incident of a green turtle taken by one of the dredges in the St. Marys Entrance. This animal passed at high speed through the hydraulic system of the vessel and was discovered in the hopper. Perhaps green turtles are naturally lucky, for this one spent a few weeks at Marineland and was then released alive. If we had loggerheads that were as small as this green turtle (12-in. carapace length), they also might come through the system alive, but they do not come to us until they are twice the size of the green and are too big to pass through the impeller pumps in one piece.

Leatherback sea turtles are regularly present outside the jetties, but we never recorded an incident where a dredge appeared to endanger them. The leatherback, largest of all the sea turtles, is not usually disturbed by the presence of a dredge, since it stays on the surface of the water and does not come into contact with the intake ports on the dragheads. Leatherbacks rarely come closer than a mile or two into shore and are most commonly seen in early spring when large numbers of jellyfish are present.

Results of the Observer Program

There have been 11 sea turtle incidents of concern, 10 involving the loggerhead sea turtle and 1 involving the green sea turtle that I mentioned earlier. All except one of the loggerheads were subadults, reflecting the relative numbers of adults (10 percent) to juveniles (90 percent) that we believe exist in the local population. Sea turtles taken by shrimp trawlers and the stranded turtles found dead on the beaches in this area of the Georgia Bight occur also in roughly the same ratio of adults to juveniles.

There were numerous sightings of live loggerhead and leatherback sea turtles that we considered to be minor incidences, since the animals were apparently not affected by the presence of the dredges. In addition, crew-boats shuttling between dredges and the mainland recorded many observations of sea turtles inside the jetties, but these animals also did not appear to be affected by the hopper dredges or the cutterhead dredge "Carolina." In addition, there were at least 20 suspected incidents where unidentified tissue fragments were collected from screens for later identification, but most of these fragments proved to be either portions of sharks or rays or of unknown origin.

One challenge of the observer program was to keep separate, if at all possible, the impacts on sea turtles by the shrimping industry working side by side with the dredging industry in the St. Marys Entrance. Several floating dead loggerheads were observed near the dredges, but the cause of death of these animals could not be correlated with the presence of the dredges. Similarly, many of the unidentifiable fragments and two of the sea turtles entrained by the dredges were clearly rotten when found; freshness of material was an important criterion on all of our incident reports. There was no way to identify time or place or cause of death for these incidents involving rotten specimens. At blame could be the dredges, the shrimp trawlers working adjacent to and within the St. Marys Entrance channel, or one of several other possible causes of death. Turtles drowned in a trawl net can sink to the bottom of the channel and subsequently be entrained by a dredge. Also present in the screens on numerous occasions were large quantities of decomposing fish. I suspect that the rotten tissue fragments, rotten sea turtle parts, and rotten fish may have been related as to origin.

Most of the sea turtle incidents were reported from the *Manhattan Island* and the *Eagle I*, and this was to be expected. The *Manhattan Island* was consistently in compliance with endangered species regulations to screen discharge water leaving the hopper, and the ship was present during prime "turtle months." The *Eagle I* was present the longest of all the dredges, and it also was in complete compliance with endangered species observation requirements. The preponderance of incidents associated with the *Manhattan Island* and the *Eagle I* was primarily a function of season, duration of work, and exemplary cooperation from these two ships. There was no evidence that they caught more turtles per unit of drag time or were more destructive to wildlife than the other two dredges, *Sugar Island* and *Dodge Island*.

We have convened this conference to assess the effectiveness of observer programs such as the one within the St. Marys Entrance. The proportion of major incidents not reported (seen) is an unknown. There are a number of logical reasons why incidents may not be witnessed on board a hopper dredge, the most obvious being animals struck by the dragheads but not brought on board and animals or their parts brought on board but buried in hopper sediments and not collected in baskets (*Eagle I*) or skimmer screens (NATCO dredges).

Mechanics of the Observer Program

Most of my discussion on the mechanics of the observer program will focus on the dragarm, split hull hopper dredge (*Dodge Island*, *Manhattan Island*, *Sugar Island*, *Eagle I*), although observers were placed on the hydraulic cutterhead dredge *Carolina* (formally the *Jim Bean*) and we monitored the presence of the dipper dredge *Crest* in an informal way. (There were no endangered species incidences noted aboard the *Carolina*, and observers stationed on the beach to monitor the discharge water from this dredge saw no confirmed mortalities.) I will not have time in this presentation to discuss the impacts of beach nourishment on sea turtle nesting success, although a great deal of sand from the St. Marys Entrance channel was pumped onto the

Amelia Island beach. The timing of nourishment projects to avoid the presence of sea turtles and their eggs and the types of beach nourishment materials amenable to successful nesting are important elements of sea turtle mitigation plans that will receive careful consideration at other times during this conference.

Ancil Taylor from Bean Dredging Company intends to provide you with a detailed description of the mechanics of hopper dredges, but I would like to draw brief attention to several aspects of the process that have particular importance to the observer program. These involve the following:

a. The time of entrainment of the turtles in the draghead.

b. The probability that an entrained turtle will pass through the hydraulic system into the hopper.

c. The design of the collecting devices used to separate target specimens from the discharge water.

d. The efficiency of the collecting devices and the probability that a sea turtle or part of a sea turtle will be collected and not pass unnoticed into the hopper sediments.

e. The additional problem of screening lateral discharge.

f. Aspects of the loading procedure that frequently render the collecting devices inoperable, and the need for a procedural manual accepted by all involved parties.

Time of entrapment

Nearly all of the freshly dead turtle incidents were associated with night digging, indicating to me that turtles were more vulnerable to the dragheads while resting on or buried in the bottom sediments at night. It follows that turtles actively moving during daylight hours are more often able to avoid the dragheads. More investigative work needs to be done in this area. Perhaps dredging at night should be avoided if the problem continues.

Draghead design

The companies were required in the contract to "screen" the intake ports beneath the draghead with openings not to exceed 120 sq in. The reason was to prevent animals from being entrained within the system, but there was little agreement as to the efficacy of the design. Given the powerful flow of water being drawn into the ship, an animal entrapped on the underside of the draghead could never free itself while the pumps were on. While on the bottom, the massive draghead would pulverize a turtle beyond recognition; steel cables and truck tires are wrapped like string around the draghead bars. Thus, an entrapped turtle will either be drawn into the ship in pieces and possibly show up in the collecting baskets or will be held under the draghead until the pumps are turned off, at which time the carcass will sink to the bottom of the channel and not be observed. Since the pumps are always turned off before the draghead is lifted from the water to prevent airlock in the system, a turtle trapped beneath the draghead will never be seen by an observer unless it is too jammed in the mouth of the draghead to fall free. The only time I saw a draghead brought aboard with its entrance plugged with limestone rocks, there was a turtle carcass held by the force of the rocks against the bars beneath the draghead. The unanswered question is: What proportion of sea turtles are killed beneath the draghead and never observed? It is the opinion of this observer program that most sea turtles will not survive entrapment beneath the draghead and that the bars should be removed to allow the turtles to be brought on board to better assess the problem.

Collecting basket design

Discharge water flows out of the hopper in one of several ways. With the *Eagle I*, the water flows out of the hopper through large ports in the forward bulkhead of the hopper. The level of the water in the hopper is controlled by louvered gates in the ports. The efficiency of the collecting baskets placed in front of the screened discharge ports depends on their vertical placement relative to the water level used in loading the hoppers. When the water level was too low, the discharge water was screened below rather than through the collecting baskets. When the water level was too high, the baskets filled with rock and clay. In either case, the baskets were rendered inoperable under such conditions. It is recommended that future work should require a fixed water level while loading the hopper or that the collecting baskets should be able to be raised or lowered to adapt to changing water levels.

Discharge water on NATCO dredges (*Dodge Island*, *Manhattan Island*, *Sugar Island*) passes through skimmers which are funnel-shaped ports in the forward area of the hopper that pass the water via vertical standpipes through the hull of the ship. The entrance to the skimmers was screened for the observer program, thereby providing the collecting baskets required in the contract. Water level was controlled during loading by raising and lowering the skimmers. Unfortunately, the skimmer screens frequently became clogged with shell and clay fragments, rendering the screens inoperable and compromising the loading capability of the ship. It is suggested that the mesh size of the screens be increased from 2 by 2 in. to 4 by 4 in. to reduce the frequency with which the skimmer entrances become clogged.

A second problem dealt with safety of the ship. A fully loaded ship is close to its weight limit. If the skimmer screens become clogged at this time and the ship takes on additional water, there is danger of exceeding the load limit. Several captains said they would be required to dump immediately their load of sediments under those conditions or risk endangering their ship and crew. Since none of the captains were prepared for the wording in the contract, a special compensation was obtained to remove the screen from a half of one of the skimmers. The number of specimens lost in this manner through the unscreened skimmers could not be determined. Dialogue should be initiated with captains and mates while the requirements of the observer program are being developed.

Collecting basket efficiency

It became apparent early in the observer program that the efficiency of the collecting baskets was questionable. Specimens observed on the screens during the loading process were frequently not present at the end of the loading cycle, suggesting that biological specimens equal to or greater in density than the water were not being seen with regularity. The questions raised are: Do fragments of sea turtles entrained by the dredges tend to float, or do they sink with regularity into the sediments of the hopper and fail to be recorded?

Lateral discharge

The requirements for loading silt and fine sand differ from the requirements for loading heavier materials. In the former case, loading efficiency is frequently gained by raising the water level in the hopper to its highest and by permitting discharge water to flow laterally over the sides of the hopper rather than forward to the skimmers. Screening the discharge water may be done along the inside of the hopper, but in this case biological samples are kept within the hopper sediments and are not observed. Alternatively, the screens may be placed on the outside of the welldeck, where all materials captured by the screens may be observed and accessed. However, screens impede the activities of the crew on the welldeck, and the amount of organic debris captured per load can be more than can be removed by an observer, thereby requiring crew assistance. Observer program constraints on lateral discharge and/or the placement of devices for screening lateral discharge water must be cleared in advance by the ships' captains to avoid misunderstanding. It is not sufficient for a land-based company engineer to agree to a "no lateral discharge" ruling unless the captain aboard the dredge also agrees before dredging commences at the site.

Loading problems

The loading of a hopper dredge is controlled on the bridge by a two-man team. The mate controls the attitude of the ship, while the dragtender controls the digging, pumping, and loading of the dredged materials. The carefully orchestrated techniques used by the mate and dragtender are difficult to change, having been acquired from years of experience. As a part of these normal techniques, skimmer screens are periodically flushed throughout the loading cycle with a massive, high-velocity flow of water, thereby washing into the hopper any specimens that might have been collected. Specimens observed on the screens prior to flushing rarely reappeared on the screens afterward, suggesting that an undetermined number of important biological specimens were being lost in the sediments of the hopper without being recorded. It is possible to avoid flushing the collector screens, but loading techniques have to be adjusted carefully, and the directives for any adjustments must pass from the captain to the mates and then to the dragtenders. An observer program exerts enormous stress on the captain and crew of the ship when not properly implemented. The complex requirements of a working dredge must be considered during the negotiating phase of an observer program. Negotiators must include dredge crew as well as company engineers. The final agreement must be incorporated into a procedural manual that will be read and acknowledged (with signatures) by all of the following parties: biologist observers, Corps personnel, NMFS personnel, company executives, company engineers, ship captains, and shipmates. All of this must occur before dredging begins, or the same bitter misunderstandings will reoccur that have plagued the success of every observer program to date.

An important consideration affecting the design and implementation of the St. Marys Entrance observer program was the nature of the dredging required. Construction and maintenance are two basic dredging categories that differ in their engineering requirements. We were involved with construction dredging that required the removal of materials never cut before, including limestone rock from old Pleistocene reefs, dense clay deposits, and a variety of other materials that were difficult to cut and load. The engineering design of the dragheads and the procedure for loading the ships had to be changed continuously to deal with the varying properties of the materials. The efficiency of the observer screens varied accordingly.

Maintenance dredging is usually a more manageable task for engineers. Dredged materials have been recently deposited and tend to be loosely compacted sand or silt. Accordingly, performance expectations placed on the dredging industry for compliance with an endangered species observer program can be greater for maintenance dredging than for construction dredging. The techniques we discuss during this conference for documenting and mitigating impacts upon sea turtles should specify applicability to one or the other of the dredging categories. In fact, the complexity of problems experienced during construction dredging at St. Marys Entrance suggests that we focus on the problems of maintenance dredging that represent the long-term effort and not worry about the problems of construction dredging that should soon be over in this area.

In conclusion, the problems observed to date with sea turtles and dredging in the St. Marys Entrance channel have not been severe. The number of documented impacts with turtles has stayed within acceptable limits. We would expect the behavior of the sea turtles in the channel to change in the coming years because of the changes that will be made to the channel, so it is impossible to predict the magnitude of future impacts resulting from maintenance dredging. There are many loose ends in the efficiency, reliability, design, and implementation of the observer program as it stands today. It is imperative that steps be taken now, at this conference, to improve the quality of the observer program so as to stay in compliance with the ESA.

RESOLUTION OF DREDGING IMPACTS ON SEA TURTLES BY THE GALVESTON DISTRICT

by

Robert Hauch*

The Galveston District encompasses coastal Texas from Louisiana to Mexico. The primary responsibility of this District is to maintain the 1,000 miles of navigation channels in Texas, which comprise shallow, as well as deep, draft channels and include seven jettied entrance channels.

Of the five species of sea turtles listed as threatened or endangered in Texas, the NMFS indicated that only three species may be possibly affected by maintenance dredging activities. These are the loggerhead, the green, and the Kemp's ridley. Of primary concern, however, is the Kemp's ridley, which is perhaps the most critically endangered of the sea turtles.

In 1986 the Sea Turtle/Dredging Task Force was formed to evaluate the effects of dredging projects upon the turtles. This task force consisted of representatives of the NMFS, USFWS, Texas Parks and Wildlife Department, and the CE. The present recommendation of the task force is to perform trawling of the navigation channels immediately prior to and during dredging operations. The NMFS has identified Corpus Christi Bay and Aransas Bay as having the highest potential for the presence of sea turtles within the Galveston District. By way of transfer of funds, the Galveston Laboratory of NMFS has performed trawls during the progress of two dredging contracts, with a third planned later in the summer of 1988. The first two contracts entailed 77 trawls totaling about 67 hr of towing time. These trawls did not locate any turtles hibernating, or otherwise, present in the channels.

The Galveston District expects to continue working with NMFS to ensure that impacts to sea turtles are avoided while continuing to perform the needed maintenance dredging of navigation channels.

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* US Army Engineer District, Galveston, Galveston, TX.

OVERVIEW OF SEA TURTLE ENTRAPMENT STUDIES AT A POWER PLANT

by

J. Ross Wilcox*

The cooling system for the Florida Power & Light Company's St. Lucie Plant withdraws water from the Atlantic Ocean to cool the condensers in the steam-production cycle of electrical generation. Approximately 1,300 sea turtles encompassing five species have become entrapped in a canal associated with the cooling system and have been individually removed and released back to the ocean.

In 1980, Florida Power & Light Company in consultation with the NMFS, the Nuclear Regulatory Agency, and the Florida Department of Natural Resources began a 4-year multifacited laboratory and field study on methods to minimize sea turtle entrapment. Methods evaluated included lights and bubble curtains, electrical fields, pneumatic guns, strobe lights and bubble curtains, and engineering alternatives. Evaluation reports were written for each method.

After careful evaluation of the legality, costs, and practicality of each method, the consensus of all consulted groups was that the physical removal of turtles by netting was the most expedient method to handle sea turtle entrapment.

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* Environmental Affairs Department, Florida Power & Light Company, Juno Beach, FL.

TECHNICAL SESSION II

James D. Hilton,* Chairman

CANAVERAL HARBOR ENTRANCE CHANNEL OPERATIONAL MEASURES TO PROTECT SEA TURTLES

by

Stephen A. Berry*

Canaveral Harbor entrance channel is a Federal project authorized in 1945 as a 27- by 300-ft channel. The project has been widened and deepened several times to accommodate larger commercial shipping and the development of the Navy TRIDENT Submarine Base. The channel is maintained annually to provide a required depth of 46 ft mean low water with a 400-ft width. The shoal material is mostly soupy silt and sand with isolated pockets of clay. The project is required to meet State Water Quality Certification, comply with the ESA, and provide a navigable channel for commercial interests and national defense.

Historically, sea turtles were not an issue until 1980. Major construction dredging had occurred in 1976 with development of the TRIDENT base. Minor maintenance dredging was conducted in subsequent years until 1979 when Hurricane David tripled the amount of shoal material. About that time, shrimpers began reporting increased numbers of sea turtles in their nets. During the 1980 maintenance dredging contract, approximately 2 million cubic yards of material was removed by hopper dredge and placed in the designated ocean disposal site. Seventy-one sea turtle mortalities directly attributed to the dredging were documented. Recognizing the need to address this issue, the Sea Turtle/Dredging Task Force was formally established by the Jacksonville District in May 1981. The task force was composed of representatives from the NMFS, USFWS, Florida Department of Natural Resources, US Navy, and the CE. The task force was designed to be a small working group with technical experts brought in to address specific areas.

* US Army Engineer District, Jacksonville, Jacksonville, FL.

The task force identified three major focal points:

a. Turtle population information primarily in Canaveral Harbor.

b. Information regarding sea turtle movement and behavior modification.

c. Dredge modifications to reduce turtle take.

This paper will concentrate on the last point. There has not been much success in the last 8 years identifying practicable ideas for behavior modification. The jetties to the outermost part of the channel are approximately 34,000 ft (over 6 miles) all of which provide suitable habitat for turtles. Measures either tested or discussed include sonic pingers, color Fathometers to identify turtles in the water column or sediment, side-scan sonar, radio tracking, and bubble screens.

Despite these efforts, the reduction since 1980 in sea turtle mortalities or "take" during dredging in Canaveral is a result of operational changes and possibly changes in the turtle population itself.

Changing the type of draghead may be the most significant operational difference. In 1980, the contractor's dredge was using an IHC draghead. This draghead was changed to a California-style draghead in subsequent contracts because the IHC draghead was believed to sit more upright with its opening acting like a scoop. The California-style draghead is thought to sit flatter in the sediment, being less likely to take turtles. Though not documented, the California-style draghead may have a "cow-catcher effect" as it plows through the sediment. The documented turtle take by hopper dredges in the Canaveral Entrance channel has dropped from 71 in 1980, to 13 in 1983, 3 in 1986, and less than 25 in 1988. The 1988 contract was the largest contract in terms of cubic yards removed since 1980 (approximately 1.5 million cubic yards) and employed three hopper dredges at one time.

The Corps did test a "cow-catcher" turtle deflector in 1981 on the Corps' dredge *McFarland*. The deflector was constructed using 1/2-in. steel plate anchor chain. The deflector was designed to pivot with the movement of the draghead. Unfortunately, this deflector was crushed in a matter of minutes. Following discussions at the National Sea Turtle/Dredging Workshop in Jacksonville in May 1988, and subsequent meetings at the US Army Engineer Waterways Experiment Station (WES) in Vicksburg, MS, two new conceptual designs for turtle deflectors were selected for testing. The two dredging contractors awarded separate contracts for the 1988 maintenance of Canaveral individually selected the concept they felt would be workable with their respective dredges. One design was for a rigid deflector made of steel plates welded to the front of the draghead in a parallel V-shaped pattern. The 1/2-in. plates were spaced 10 in. apart and varied in height from 24 to 43 in. high. The bottom of the plates was 6 in. below the horizontal plane of the draghead when the draghead was dredging at the required depth of 46 ft. A minimum of 6 in. below the horizontal plane of the draghead was necessary to deflect the turtles deeper into the sediment and away from the suction of the draghead. This deflector was rendered ineffective due to loss of plates within 3 days of dredging and actually impinged two turtles, resulting in their deaths. The second deflector was a flexible chain webbing forward of the draghead in a V-shaped configuration attached to the dragarm and draghead. A weighted ball, which was actually a solid steel 12-in.-diam shaft, was installed at the low forward end of the "V" to help the 1/2-in. chain webbing maintain its shape out in front of the draghead. This flexible deflector maintained its integrity during the week-long test period and was left on for the remaining 3 weeks of the contract. One small green turtle mortality was documented during this time. This turtle was small enough to fit through the chain webbing. Although the trial results are still undergoing review, the flexible deflector showed the greater potential of the two deflectors. Its integrity was maintained with a minimum of repair, it did not affect production, and no turtles larger than the webbing were killed over a 4-week period. Conversely, the rigid deflector was ineffective, taking two turtles in less than 3 days and claimed some loss in production. Further investigation into the rigid deflector approach is not recommended.

The monitoring of turtle mortalities associated with dredging has also been investigated. Screening of overflow, either through skimmers or overboard with inspection by sea turtle observers, has been required on all hopper dredges in the Canaveral Entrance channel since the early 1980's. The exact screening design has been dictated by the particular dredge awarded the contract. There is a general consensus that the documented turtle mortalities underestimate the actual take when only the overflow is screened. Studies have indicated there is insufficient upwelling of material, even light silty material, within the hopper to force larger remains of turtles to the screens. The 1988 Canaveral maintenance work was the first time inflow screening was instituted. This screening was installed on one dredge near the completion of the project. Investigations into the practicality of inflow screening continue. The variability of internal discharge piping into the hopper inhibits a generic design to screen inflow. The type of material being dredged and the safe retrieval of parts by turtle observers are major considerations. It is very important to effectively screen the material so that the actual impact of dredging to sea turtles can be assessed. This assessment will also determine the effectiveness of measures to reduce turtle mortalities.

The Jacksonville District has plans to test alternative methods of dredging in Canaveral Harbor in the summer of 1989. Two contracts awarded to clamshell dredges within the past 4 years did not result in any documented turtle mortalities. However, neither contractor was able to provide the required depth as the hopper dredges have done in Canaveral. Contractors have stated that better weather would let them overcome difficulties with removal of the silty material. The NMFS has extended the dredging window into the summer allowing optimal dredging weather for the clamshell and pipeline dredge trials. The second alternative dredge type, a hydraulic pipeline dredge with spider barges for ocean disposal, has not been used in the Canaveral Entrance channel. The relatively slow dredging motion of clamshell and pipeline dredges would likely further reduce turtle mortalities, but the practicality and safety of placing them in exposed ocean waters for long periods will be tested. The ability to provide the required depth in timely fashion and at a reasonable price is also in question. We will be able to address these questions in the fall of 1989.

The Corps has a mission to provide safe navigation and meet national defense requirements in Canaveral Harbor. We also recognize our responsibilities with regard to the ESA. We have graduated from a confrontational mode with the resource agencies, both State and Federal, to a cooperative mode in order to accomplish our respective duties. The Corps will continue to work in this manner in Canaveral Harbor and other Federal projects to reduce turtle mortalities from dredging operations.

INTRODUCTION TO ALTERNATIVE DREDGING METHODS

by

Michael R. Palermo*

The dredging methods employed by the CE vary considerably throughout the United States. Principal types of dredges include hydraulic pipeline types (cutterhead, dustpan, and plain suction), hopper dredges, and clamshell dredges. Other dredges include sidecaster, dipper, ladder, and special purpose dredges. However, there are basically only two mechanisms by which dredging is actually accomplished:

a. Hydraulic dredging. Removal of loose materials by dustpans, hopper, hydraulic pipeline, and sidecaster dredges, usually for maintenance dredging projects.

b. Mechanical dredging. Removal of loose or hard, compacted materials by clamshell, dipper, or ladder dredges, either for maintenance or new work projects.

Selection of dredging equipment and method used to perform the dredging will depend on the following factors:

a. Physical characteristics of material to be dredged.

b. Quantities of material to be dredged.

c. Dredging depth.

d. Distance to disposal area.

e. Physical environment of and between the dredging and disposal areas.

f. Contamination level of sediments.

g. Method of disposal.

h. Production required.

i. Type of dredges available.

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* US Army Engineer Waterways Experiment Station, Vicksburg, MS.

CLAMSHELL DREDGES

by

Brian Lindholm*

Great Lakes Dredge & Dock Company operates clamshell dredges, cutter-suction dredges, and hopper dredges and is substantially larger than any other dredging company in the United States.

One may wonder why a particular type of dredge is working in a certain environment and task when one sees a hydraulic, hopper, or clamshell dredge. It must be known that each contractor may look at a task differently. We have recently undertaken deepening projects thinking that a clamshell or hopper dredge was better and found out after we bid the job that in fact the tool we thought to be less effective turned out to be the most effective.

Considerations for how clamshell dredging fits into categories of dredging or types of dredging include the following:

a. Distance to the disposal area.

b. Types of material being dredged.

c. Environmental concerns.

d. Configuration of the cut.

e. Speed of mobilization.

The material dredged by a mechanical dredge is usually placed in barges and transported by tugboat to an offshore disposal area. Material can be pumped directly (or with pipeline dredges) to the disposal area up to 4 or 5 miles; otherwise it must be loaded onto barges to be economical. Another dredge may be used to pump out a barge that has been loaded with either a clamshell or hydraulic dredge into a diked disposal area. Material can be taken a hundred miles offshore by a hopper dredge or in a barge loaded hydraulically or with a clamshell dredge. A hopper and clamshell are both competitive in any job with a disposal site distance between 4 and 20 miles, probably a hopper dredge more in sand and the clamshell more in silts. Over 20 miles, unless it is a big hopper dredge, it becomes more economical to use a clamshell.

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* Great Lakes Dredging, Staten Island, NY.

Therefore, although an important factor, distance to disposal area is not going to alone eliminate certain dredges. This is a very big factor, costwise, but it does not limit any dredge by making it not capable of doing a dredging project.

One of the best jobs for a clamshell dredge, as opposed to a hopper dredge and cutterhead dredge, is to demolish or remove debris, old bridges, or piers. This is where a clamshell can be most effective as compared with other dredges.

There are various types of maintenance dredging buckets for various tasks. If you were going to attempt to dig rock with a clamshell, you would use one with teeth. If you were going to dig silts, you would use a lightweight bucket. There are various bucket sizes and weights.

Generally speaking, the clamshell dredge is better than any other tool for debris. It is also very good for silt. It is probably as good or better than a hopper dredge in hard clay. It is not good in sands. Sands tend to be pumped easier than they are penetrated, and we have difficulty digging sand with clamshell dredges.

Clamshell dredges have also been used to:

a. Build dikes (Hart-Miller Island).

b. Deepen channels (Thimbleshoal, Virginia).

c. Build levies for hurricane protection (Golden Meadow).

Hopper dredges are easy to mobilize. We had mobilization of two dipper dredges in Panama last year, and we had to do it fast. It was a difficult and expensive task, but it can be done. It is just more expensive. In Cape Canaveral, we have dredged with both a hopper dredge and with a clamshell dredge.

You could dig Canaveral with a spider-barge, a hydraulic dredge, pump it into barges, and take it to the ocean. You can do it with a clamshell dredge in the summertime, but you should not dredge mechanically in Canaveral during October, November, or December, when you have winds out of the east at 20 knots almost steadily.

HYDRAULIC CUTTERHEAD PIPELINE DREDGING

by

Leon Hrabovsky*

History

The first hydraulic cutterhead pipeline dredge in the United States, and probably in the world, was designed and built in 1874. It is possible that 20 years earlier water and a centrifugal pump were used to move material, but it was not transported any length through pipelines. The first dredge pump was approximately a 12-in.-diam discharge.

The modern-day hydraulic cutterhead pipeline dredge has advanced a great deal since that early beginning. We now have 30- to 42-in.-diam pump dredges with 15,000 to 20,000 installed hp. These dredges are capable of pumping certain types of material through 5 to 6 miles of pipeline.

Components and Operation

The cutterhead pipeline dredge is essentially a barge hull with a centrifugal pump mounted inside, driven usually by a diesel engine or electric motor. Also mounted inside the hull are generators that supply electric power to various motors throughout the dredge. Attached to the bow of the dredge is a ladder, which can be raised to the horizontal position or lowered to the desired digging depth. The ladder is equipped with a cutter shaft; a cutter, which is attached to the shaft; and a power supply that turns the cutter. There is also a suction pipe, which begins just inside and behind the cutter and continues up the ladder through the bulkhead at the bow of the dredge to the main pump. The material that is cut by the cutter is sucked up in the suction, through the main pump, and out the discharge side of the pump and to the stern of the dredge. At the stern, the pipe connects to a floating pontoon line and continues through the floating line and/or combination of floating submerged and landlike to its final destination, the disposal area. The dredge can advance ahead by swinging from side to side with the two swing

* T. L. James & Co., Kenner, LA.

hoists located on the port and starboard bow, and stepping ahead with the two spuds mounted on the port and starboard stern. The speed at which a dredge can advance depends on several different dredging conditions. The hardness of the material, the thickness or depth of the cut, the width of cut, and the distance between the cut and the disposal area, all determine the speed at which a dredge can advance.

For example, a dredge digging hard rock may advance 5 to 10 ft/hr, while on the other hand, a dredge digging very soft silt may advance in excess of 100 ft/hr. Dredge sizes vary mainly because of two situations. One reason is the size or depth of the project being dredged, and the other is the size of the disposal area in which the dredged material is placed.

There are several types of disposal areas, but probably the three most common are open water, upland confined diked, and beach disposal areas or fill areas. The open-water disposal area is usually adjacent to the dredge cut and continues parallel to the channel. The dredge can pump directly into these areas through a floating pontoon line. This type of disposal area is becoming obsolete in some cases as the result of environmental regulations. The upland confined diked area is an area that requires a pipeline running ashore to transport the material. The dredged material is pumped directly into the area, and after the solids settle out, the water is drained back to the channel or bay by means of an overflow weir and drainage pipes.

The beach disposal and/or fill area is another type of disposal site. This area is becoming a popular and common means for disposing of material. It serves a dual purpose, in that it is also a good means for renourishment of beaches. The only requirement for this disposal is that the material being dredged is suitable for beach fill. The material best-suited for beach nourishment is fine or medium grain-size sand.

Capabilities and Limitations

The hydraulic cutterhead pipeline dredge is an economical way to move material a relatively short distance, which would be approximately 1 to 3 miles. For heavier materials, additional booster pumps are required when pipeline lengths exceed 3 miles. In some instances, it is more economical to add several booster pumps than it is to use a different dredging method. This occurs when the only route to a disposal site is overland. The modern-day cutterhead pipeline dredge is capable of dredging materials ranging from soft silts to very hard rock. Rock with a compressive breaking strength ranging from 15,000 to 20,000 psi has been cut with a cutterhead pipeline dredge.

The cutterhead pipeline dredge is limited as to the sea conditions in which it can economically operate. Rough seas reduce the efficiency of the dredge and also cause damage to the floating pipeline, and in some instances, to the dredge itself. The pipeline dredge is also limited when disposal areas are a great distance from the dredging site. When the distance between the disposal and dredging site exceeds 5 miles, it is usually more economical to use other dredging methods, if possible.

Future

The future of the hydraulic cutterhead pipeline dredge depends mainly upon the availability of disposal sites. As mentioned previously, when a disposal area and pipeline right-of-way are provided within a reasonable distance of the dredging site, the pipeline dredge is a dependable and economical method of transporting material.

THE HOPPER DREDGE

by

Ancil S. Taylor*

History

The modern hopper dredge, a highly specialized piece of dredging equipment, has evolved through recent years to meet the requirements of increased drafts for modern shipping. These increased depths must be carried farther and farther offshore to meet the natural contours of the sea. The hopper dredge was first used in the United States by the CE in 1855. The *General Moultrie*, a 364-ton hopper, dredged over approximately 3,000 cu yd/day. The technology was developed further by the Europeans while few improvements were made to the US Fleet until recently. This development overseas was fueled by the increasing competition worldwide in the hopper dredging market. With recent Congressional legislation, a large portion of our hopper dredging projects was to be contracted by the Corps to the private sector. With the element of competition present, the United States has developed one of the most modern dredging fleets to be found in the world.

Why a Hopper Dredge

The hopper dredge fills two basic requirements for most offshore dredging projects. The first and most common is the need to work "sagely" in adverse sea conditions. The second is the transportation of dredged material from the dredge area to the fill or disposal site, be it short or long distance. Were it not for these two requirements, the dredging could probably be done more efficiently with other types of dredging equipment. A hopper dredge provides a safe working environment for crew and equipment to effectively dredge bar channels or other areas subject to rough seas. It also enables dredging work to be done concurrently with shipping operations as the hopper dredge may sail the channel along with existing traffic. It is a self-contained vessel and usually works alone, not depending on other equipment or

* Bean Dredging Corp., New Orleans, LA.

boats that may be vulnerable to offshore conditions. This also adds to its mobility as it is probably the most mobile type of dredge there is. The hopper dredge fills a very necessary requirement for dredging of channels in an exposed environment.

Characteristics of a Hopper Dredge

A hopper dredge generally takes the shape of an ocean-going vessel or ship. It has a bow that allows for as efficient movement through the water as possible and still has space for all the machinery that must be close to the bow and low to the keel. It has a cargo hold that is placed in a location structurally sound for the vessel. It has crew quarters which must be comfortable for the long hitches the crew must pull, yet space and weight efficient to maximize payload. The hull is built to accommodate all propulsion machinery, fuel, and all supplies it will need for as long a period as possible to minimize time for refueling and replenishing consumables. The design of a hopper dredge requires many trade-offs or sacrifices because of available weights, dimensions, and dollars.

Operation of a Hopper Dredge

A hopper dredge removes material from the bottom of a channel in thin layers, usually 2 to 12 in. The depth depends upon the density or compaction of the material, or its "dredgeability." Pumps, usually within the hull but sometimes mounted on the dragarm, create a region of low pressure around the draghead. This forces water and solids to rush into the draghead and up the dragarm to the area of lowest pressure, the eye of the pump. Once here, the material is propelled beyond the pump in a centrifugal manner with the use of vanes. The force created from water and solids rushing under and into the draghead is much the same as the force that lifts an airplane wing when air rushes over the top of it. This force, in addition to the negative buoyancy of the draghead assembly, causes the draghead to "seat" itself and help maintain contact with the bottom. Proper draghead design allows for minimum necessary venturi force while maximizing solids concentration into the draghead.

The dredge pumps of a hopper should be located at an elevation in the design of the ship that would place them no higher than the water's level when the ship is at minimum draft. This will assure priming and minimum loss of available suction head for lifting the slurry from the channel bottom.

From the bottom, into the draghead through the dragarm and the pump, the slurry is introduced into the hopper. The slurry travels through an arrangement of discharge piping designed to reduce the velocity or energy of the slurry to a minimum. It is now the dredgeman's desire to retain as much of the solids in the hopper as possible. This is done by minimizing turbidity within the hopper and allowing the natural settling velocity of the grain to be the prevailing force or vector. If this is accomplished, maximum settling will result. A hopper dimension that allows for minimum velocity of flow from the entrance of the hopper to overflow and the longest travel distance available will allow maximum retention within the hopper. It is the dredgeman's responsibility to determine the optimum mix between flow of slurry into the hopper and minimum loss of solids through the overflow. The dredgeman must be careful since decisions made in this area of production may affect efficiency of the draghead; so constant awareness of all production parameters is necessary.

Dredging is normally done parallel to the center line or axis of the channel. Sometimes a waffle or crisscross pattern may be utilized to minimize trenching and produce a more level channel bottom. The dredging of the channel is called trailing and may be done at speeds of 1 to 6 knots, depending upon the conditions of the project. The mate, or person at the helm, trails the ship over areas in the channel where material must be removed. With a good survey positioning system and a proficient helmsman, areas as small as 15 sq m can be bullseyed by a 10,000-ton vessel. Trailing will continue until the ship is fully loaded or the cycle production is optimized, whichever is first. It is important to maintain a constant analysis of the cycle production as loading the ship to the top does not always pay. Normally, the longer the haul distance, the more advantageous it is to pack the hopper full.

Once loading is complete and all overflow has been drained from the hopper, the sailing portion of the cycle begins. All dragarms are heaved aboard, a course is laid to the disposal area, and throttles are thrown forward. Maximum speed is the all-important factor here, second only to the shortest distance available.

Upon arrival at the disposal area, the dump cycle begins. A disposal plan has been laid out to minimize time spent and to assure total discharge of dredged material. Most hoppers either split in half along the axis or hull or have bottom doors that open downward to empty the hopper. Some hoppers may have to be pumped out.

At the completion of the dump cycle, the return sail portion begins. Upon returning to the dredge area, the cycle begins again. This cycle is normally continued 24 hr/day for 7 days/week until the project is completed.

Capabilities and Limitations of a Hopper Dredge

A hopper dredge can work in almost any area that a ship can sail, and some hoppers have worked in some areas where a ship would never sail. A hopper dredge must have enough depth of water in front of the ship to sail over the area to be dredged, unlike other types of dredges that can dredge a new channel through the Sahara, if necessary. A hopper has difficulty dredging hard or very hard materials such as clay, rock, or coral. Some hoppers have increased propulsion power and heavy and even automated dragheads, but efficiency in this type of materials does not compare with other more suitable types of dredges.

Slope dredging and trailing next to bulkheads or docks are difficult for a hopper dredge. Controlling the position of the draghead and maintaining close proximity to the dock while trailing are very demanding and inefficient. Dredging in areas where large amounts of trash or rubble exist is inefficient, whereas clamshell or bucket dredges may not be as hindered in their production. As mentioned earlier, the hopper dredge is a special tool that does its suited project more efficiently than most other types of dredges.

The Future of Hopper Dredges

Based on most companies' cost recoveries and depreciation periods, the hopper dredge will be here into the beginning of the next century. Shipping drafts are expected to increase; thus ship channels will be deepened to accommodate them. There do not appear to be any practical alternatives to hopper dredging on the horizon for removal of material from the channels out to the natural contours. Although some modifications and improvements are expected to enhance the production process, the general condition of hopper dredging will remain much as it has been for 100 years: "Load and Go."

TECHNICAL SESSION III

Ross Witham,* Chairman

SEA TURTLE HIBERNATION IN THE CAPE CANAVERAL SHIP CHANNEL

by

Peter L. Lutz**

The surprising discovery that large numbers of sea turtles bury in the anoxic mud in the Cape Canaveral ship channel for unknown periods of time posed the question of why they are there. It is possible that in some winters turtles survive cold temperatures by going into a state of protected hibernation. At other times, burial in the anoxic mud may have beneficial effects, such as purging external parasites and barnacles, in which case, submergence would have to be prolonged, outlasting the capacity of the parasites to live without oxygen.

Recent reports suggest that this behavior might be much more widespread such that the Cape Canaveral ship channel, and similar habitats, could be of special importance to sea turtles in their struggle for survival. To assess the significance of this peculiar behavior, it is necessary to establish if the buried turtles are in a special physiological condition that minimizes oxygen requirements (hypometabolism) and if cold winter submerged turtles are actually in a state of hibernation. For practical purposes, it is also necessary to find out how the buried turtles can be moved and handled with least disturbance and without jeopardizing their survival.

Changes in blood chemistry indicate changes in metabolic state. We have established a blood chemistry profile for normal, active loggerhead sea turtles living in Cape Canaveral waters and identified the effect of temperature on the blood chemistry and respiration of loggerheads.† These

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* Consultant, University of Miami, Miami, FL.

** Rosensteil School of Marine and Atmospheric Science, University of Miami, Miami, FL.

† P. L. Lutz, A. Bergey, and M. Bergey, "Effects of Temperature on Respiration, Blood Gases and Acid Base Balance in the Sea Turtle, *Caretta caretta*," article in preparation.

P. L. Lutz and A. Dunbar-Cooper, 1987, "Variations in the Blood Chemistry of the Loggerhead Sea Turtle *Caretta caretta*," Fishery Bulletin, Vol 85, No. 1.

data can be used to identify hibernation and hypometabolism, of particular importance are plasma magnesium and calcium levels (which proved to be very conservative under normal circumstances) and blood lactate and glucose concentrations.

It is recommended that blood samples be taken from turtles that have been submerged in the mud for at least several days (identified by telemetry) in order to establish their physiological state. It is also recommended that a laboratory study be made on the physiology of hypometabolism in loggerheads with particular attention being paid to the effects of disturbance.

RADIO TAGGING OF SEA TURTLES

by

Edward Standora*

Two main types of telemetry can be applied to the study of sea turtles: radio and sonic telemetry. Each has unique properties that make it more or less desirable depending on the particular application. Radio telemetry is the sending of information using electromagnetic waves emanating from an antenna, while sonic telemetry sends sound waves through a liquid medium. Radio signals at the frequencies used for wildlife studies (148 to 174 MHz) travel very poorly through water with a high ionic content and therefore are unusable for marine organisms that do not surface. For animals that do surface, transmission is limited to the period when the antenna is exposed above the surface. The suitability of radio transmitters for sea turtle research varies widely depending on the species being studied, size of the animal, location, and parameters being monitored. For example, preliminary data suggest that leatherback turtles spend more time at the surface than do ridleys, making the former better candidates for radio telemetry.

Radio transmitters require less power than sonic systems and therefore will have greater range and/or life for a given battery size. Radio signals also have the advantage of being able to be detected from aircraft equipped with the proper antennas, allowing the researcher to survey large areas quickly. This advantage is meaningless, however, if the transmitter is attached to an animal which spends a large percentage of its time below the surface. Often researchers find the directionality of radio signals to be more ambiguous than the precise directionality of sonic signals. This effect can be greatly influenced by the type of antenna and hydrophone used.

Sonic transmitters provide a means of monitoring a sea turtle continuously regardless of where it is in the water column. Sensors for temperature and depth can be incorporated in these packages. A problem with sonic telemetry arises if the animal being tracked enters areas of high ambient noise. Some possible causes of interfering noise would include turbulent water discharges, proximity to surf zones, and rough sea conditions. In some areas the biota (e.g. snapping shri) can generate interference.

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* State University College, Buffalo, NY.

Areas with strong density gradients can also cause a problem when the animal is below the interface layer and sound is reflected downward, away from the investigator. Sonic receivers have an advantage over radio receivers in that models are available which can be used underwater for locating an animal, thus making it possible to directly observe its underwater behavior or easily recapture it to determine growth rates, gut contents, or other factors.

For much of my research, I have used both types of systems simultaneously. Although this approach is more expensive, it provides the advantages of both systems and the disadvantages of neither.

If a transmitter is towed by a turtle and is not directly attached to the carapace, it is important that the tether be short enough so as not to be bitten by the turtle. All such systems should also employ a breakaway link which will free the turtle in the event of entanglement.

Biotelemetry could play a valuable role in assessing the status and behavior of turtles in the Cape Canaveral ship channel. Time budget analysis could be used to determine possible diel cycles of turtle behavior which would suggest times of dredging that would minimize the impact on the turtle population. During what time of the day is there a higher probability of turtles being at the surface, at middepth in the water column, or at the bottom? These same questions can and should be addressed on a seasonal basis. Are certain areas of the channel a favored habitat? Is more time spent along the sloping sides of the channel than in the center? Again, the precision with which turtles can be located using telemetry will quickly answer these questions.

Some researchers have proposed trawling turtles from the area prior to dredging operations and releasing them elsewhere. A major question is how far away is sufficient and in what direction? The efficiency of a displacement tactic could be easily assessed by moving turtles several distances (e.g. 5, 10. and 20 km) in three different compass headings and then monitoring the time until their return (if ever). This would not be labor intensive once the turtles were outfitted and released because a plot of their travels is not necessary, only a recording of their time of arrival at the channel. It would not even be necessary for a researcher to remain stationed at the ship channel. Remote recording stations could be deployed underwater at several sites along the channel. These monitors could be retrieved weekly to determine when the turtles returned. An alternate method would be to use a sonabuoy, which detects a sonic signal and immediately converts it to a radio signal that is then detected by a shore-based radio telemetry receiver.

The idea of using devices such as submersible pneumatic guns to frighten turtles with a high-intensity acoustic discharge has also been proposed. The efficiency of such a device could easily be tested using a free-swimming turtle equipped with a telemetering device. Because a turtle's position can be determined precisely, it would be a simple matter to evaluate its response to different intensities and/or frequencies of sound, angle of presentation, and repetition rate. Once frightened, how far would the turtle move? Would it habituate to the sound? Would it soon return to the area? With the answers to these questions, we could then evaluate the feasibility of clearing an area prior to dredging by towing an acoustic repelling device perhaps minutes or hours prior to initiating dredging operations.

It is difficult to manage a resource without sufficient information. Telemetry is an effective tool which can help answer not only specific scientific questions concerning, perhaps, the blood chemistry of "hibernating" turtles buried in the sediments, or long-term biological questions, but also management questions directly and immediately applicable to the turtles in the Cape Canaveral ship channel. It is important to keep in mind that the application of biotelemetry systems to answer such ecological questions is not a new experimental approach, but has been applied successfully to marine animals for more than 20 years.

CURRENT SEA TURTLE SURVEYS AT CAPE CANAVERAL SHIP CHANNEL

by

Alan Bolten and Karen Bjorndal*

The purpose of this project is to survey the Cape Canaveral ship channel for the distribution of sea turtles so that maintenance dredging can be appropriately coordinated. In addition, secondary objectives include tagging turtles to determine movement and migration patterns and monitoring the size distribution, sex ratios, and basic blood chemistry of the sea turtle populations inhabiting the channel. One survey was completed in March 1988; two others will be conducted in May and September 1988.

The region of the channel that was surveyed corresponds to NMFS survey Stations 7 through 14. Station 7 was modified to lie completely inside the jetties (=Station m7). Each station was divided into two substations, a left side and a right side of the channel. A commercial shrimp trawler that was double-rigged with 80-ft nets with TEDs removed was chartered to conduct the survey. Two 15-min tows (left and right side of the channel) through each of the eight survey stations were conducted according to a randomized design consistent with NMFS survey protocol.

Eleven loggerheads were caught during the March survey: eight in Station 12 and three in Stations 10 and 11. Nine turtles ranged in size from 45 to 70-cm carapace length, and two ranged in size from 80 to 85 cm. The location of turtles within the channel and their size range correspond to results from earlier surveys (Figures 1-3).

No turtles were caught in Station m7 during the survey. However, because dredging activities were underway during the survey, we cannot conclude that there were no turtles present or that at another time, when dredging was not underway, turtles would not be present. The results of future surveys will be important for determining whether turtles inhabit the area inside the jetties.

When these designated survey tows were completed, additional tows were conducted in and adjacent to Station 12, where the turtle density was observed to be highest. The objective of these additional tows was to further sample

* Center for Sea Turtle Research, Department of Zoology, University of Florida, Gainesville, FL.

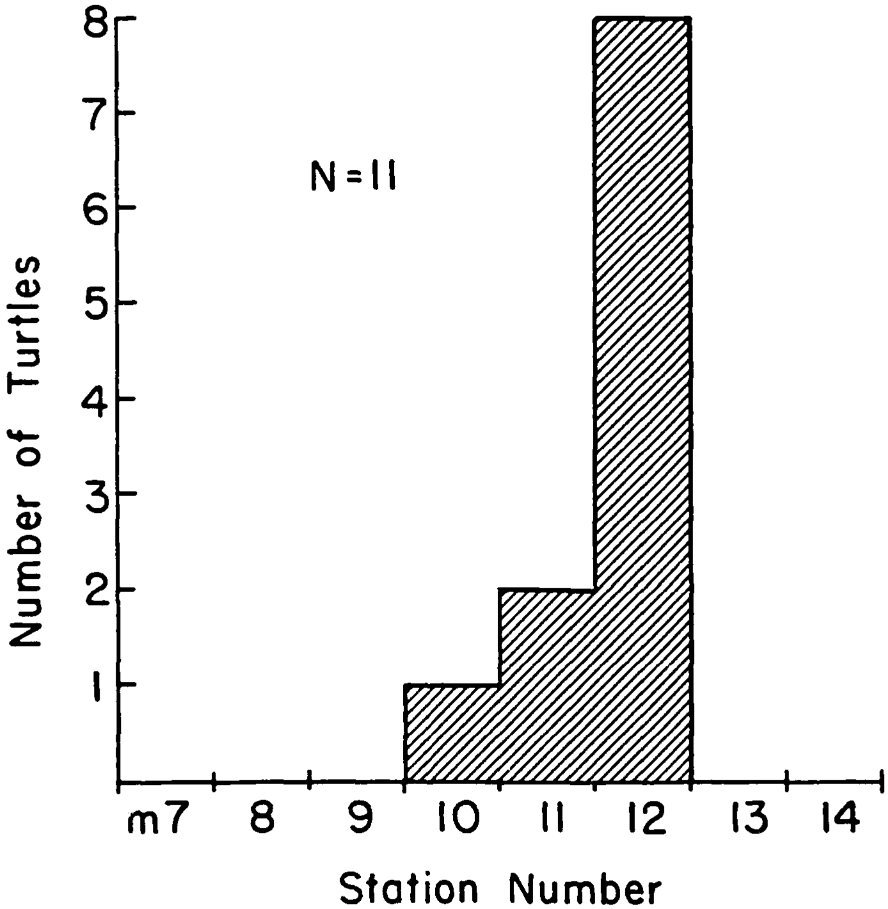

Figure 1. Distribution among stations of turtles captured during designated survey tows; m7 is modified Station 7 (see text)

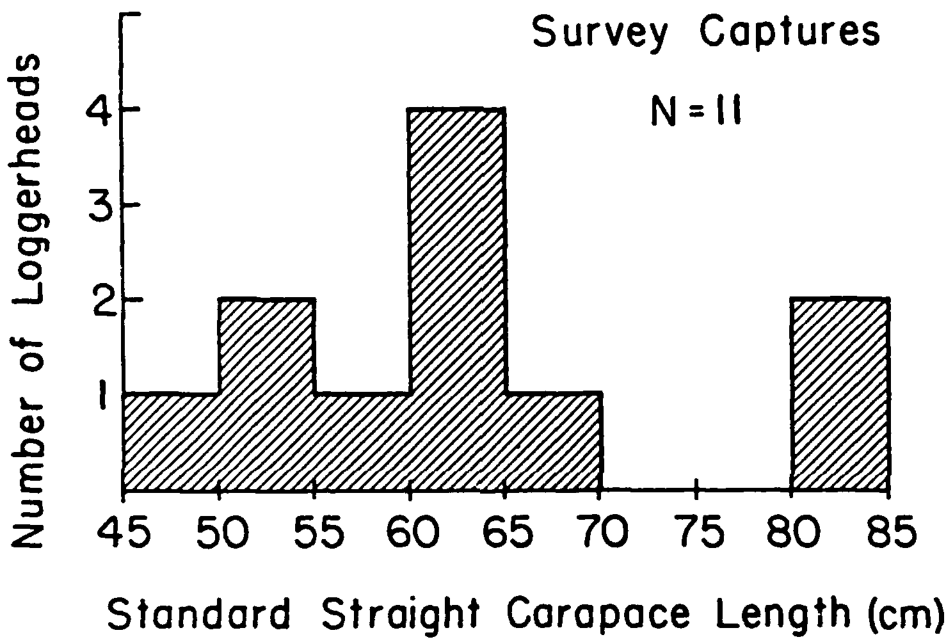

Figure 2. Size distribution of loggerheads captured during designated survey tows. Standard carapace length is measured from nuchal notch to posterior marginal tip

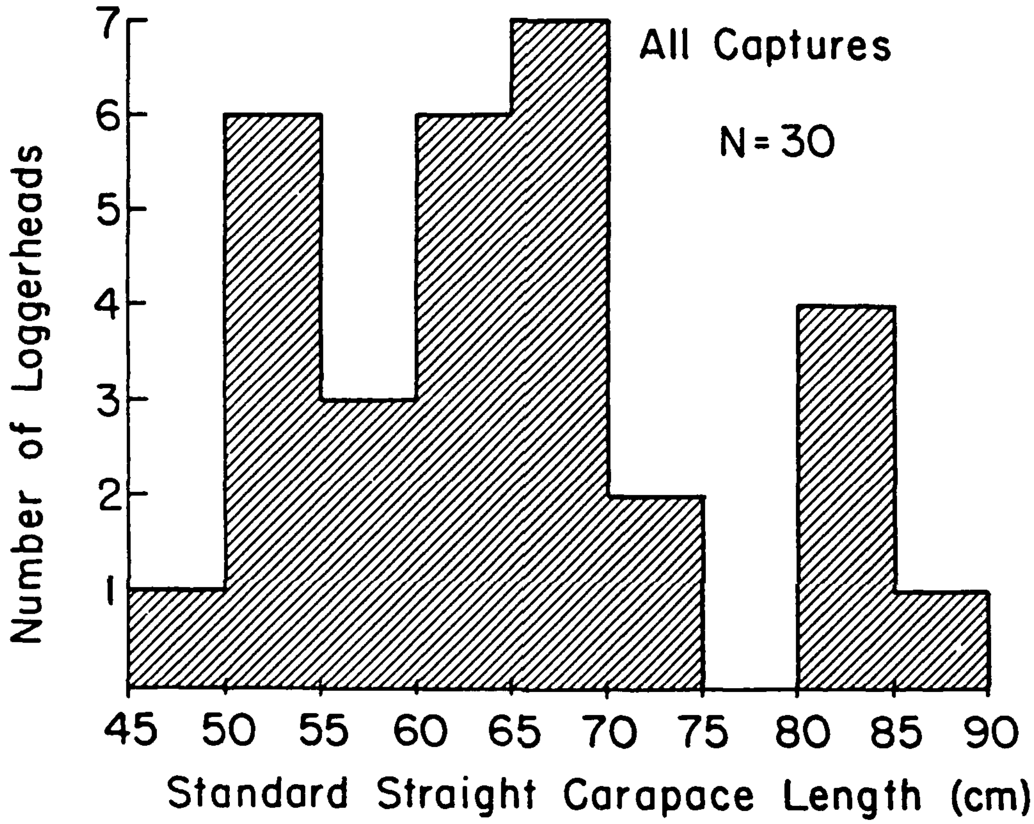

Figure 3. Size distribution of loggerheads captured during all tows (both designated survey and additional tows). Standard carapace length is measured from nuchal notch to posterior marginal tip

the size distribution and sex ratio of the population inhabiting the channel during this period. These additional tows resulted in 21 additional turtle captures including one ridley, one green turtle, and the only capture of a previously tagged turtle. The size distribution followed that observed during the designated survey. Blood samples were taken for testosterone assay to determine the sex of the immature turtles. This project is funded by the CE (Jacksonville, FL) through the US Fish and Wildlife Coop Unit at the University of Florida.

WORKGROUP SUMMARIES BY FACILITATORS

WORKGROUP 1 SUMMARY

Dena Dickerson,* Facilitator

Workgroup 1 used the suggested questions (Appendix A) provided as a guideline for the discussions. After evaluation, we felt that the majority of questions discussed were in need of more research before any answers could be decided. Many of the biological issues are in need of being addressed before definitive ways of altering the dredges or dredging operations can be implemented. We feel the research needs fall in both long- and short-term categories.

Needed Biological Studies

a. Physiolological/temperature studies need to investigate the "hibernation" state of the sea turtles.

b. Daily cycle studies need to determine where the turtles are in the water column as well as to help determine the reason the turtles are attracted to these channels.

c. Dredging impact studies other than mortality are needed.

d. Additional research is needed to test the use of sonic pingers with the dredging operations as a possible scare technique. Additional scare techniques also need to be further investigated.

A lot of biological research needs to be addressed; however, the dredging research also needs to be equally addressed. This too has both long- and short-term aspects.

Needed Dredging Studies

a. Additional dredgeheads which are presently being used in other areas of the country need to be investigated as possible alternatives. Some mentioned in the workgroup meeting were unfamiliar to all the members of the group.

b. Investigation into redesigning the cattle catcher or other deflector devices is needed for the presently used dredgeheads.

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* US Army Engineer Waterways Experiment Station, Vicksburg, MS.

c. Techniques need to be investigated that help determine the actual number of turtles taken by the dredges. A known number of dead turtles or simulated turtles need to be run through the dredges to determine what take is actually being seen. A multiplying factor can then be calculated to help figure the actual turtle take.

Although long-term studies are needed to answer many of these questions, our group came up with several things we feel can be done immediately.

Immediate Actions Suggested

a. The dredging time window can be moved up to include June through August to allow use of alternate methods of dredging with less potential turtle take. The present September-through-November dredging window limits the dredging methods to the hopper dredge because of weather conditions. By moving the dredging window up into this time slot, the options for dredging increase as far as dredging equipment choices. This allows for other dredging options in addition to the hopper dredge, whereas the hopper dredge is the only feasible choice with the present allowed window.

b. The hopper dredge could be altered to using a cutterhead with a spider barge or using the clamshell. The use of these alternatives would need procedure and/or equipment modifications such as moving the present dredging time window or allowing overflow. All of these dredging methods could be used if the dredging window were moved to June through August. At present, the hopper dredge is the only choice because of the restrictions on the dredging time. restrictions on the dredging time. As far as we know, there have been no turtles taken by the cutterhead design dredged head.

c. Additional, more thorough screening is needed to more closely monitor any turtle take.

d. Although scare tactics are questionable, we propose that sonic pingers be attached to the dredges as a possible deterrent to the turtles. This would help test their usefulness while waiting for the development of other scare techniques.

Funding for the various needed research areas needs to be further addressed and analyzed. It was proposed that the WES will serve as a central location for the information generated from the studies; however, the Center for Sea Turtle Research (University of Florida) would serve as local coordinator.

WORKGROUP 2 SUMMARY

Michael R. Palermo,* Facilitator

Subgroup 2 was composed of approximately eight CE representatives, one dredging industry representative, and five representatives of the resources agencies or their contractors. A list of prepared questions was provided as a basis for the discussions. We found that the list covered all pertinent considerations. The findings of the workgroup are summarized below and generally represent a consensus viewpoint.

Turtle Biology and Habitat Considerations

More information is needed on how turtles behave and how this relates to potential dredging impacts. Specifics are determination of the following:

a. Whether and when the turtles are predominantly in the water column or benthic environment.

b. Impacts resulting from dredging other than mortality.

c. The extent and season of any hibernation or burial activity of the turtles in the channel.

d. The turtle's reaction time to stimuli. Sufficient data on the reaction to various stimuli have already been developed by the Florida Power & Light Company.

e. The attraction of the channel areas to the turtles. This could include their attraction to low currents, dark conditions, or anaerobic sediments.

Any efforts in determining more information on turtle behavior should focus on how the behavior relates to potential dredging impacts. This would be the sole focus of any research efforts in which the Corps would participate.

Our subgroup concluded that attempts at relocation of turtles prior to dredging by trawling were largely ineffective. We also concluded that any attempts to exclude the turtles from the channel would be futile because of the large linear configuration of the channel.

Seasonal considerations were quite important. The Kemp's and greens are present January through March; therefore, no dredging should occur then. Breeding adult loggerheads are present May through August, and these are

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* US Army Engineer Waterways Experiment Station, Vicksburg, MS.

viewed as the most critical resource for protection. The largest numbers of turtles occur in the fall and winter, but most of these are juveniles. It is thought that any burial or hibernation behavior occurs in the winter, with potential for greater impacts. The present dredging window is from September through November, assuming a hopper dredge is used. However, the resource agencies would allow the window to be shifted to late spring and summer if an alternate dredging method (to include improved hopper) with less potential to turtles was used.

Mitigation or compensation for loss was briefly discussed. The ESA does not provide for mitigation, on the assumption that no loss is acceptable. However, some form of compensation for incidental loss was deemed appropriate in some instances. This might be in the form of turtle hatcheries or similar programs to attempt to build up populations. An administrative review of these provisions in the act was viewed as desirable.

Dredging Equipment and Operations

A major area of discussion centered around the potential use of cutterhead or mechanical equipment to perform the work. Hopper dredges sail at speeds of several knots. At this speed, a turtle on or in the bottom sediment has little time to move before impact. However, the swing speed of a cutter or the progress of a clamshell is much slower. The cutterhead and mechanical equipment also can remove a higher bank than the hopper. This means that mechanical equipment or cutterheads work a much smaller surface area per unit of dredging time than does a hopper and accordingly will have less potential for turtle impact.

However, the open-ocean environment of the outer channel at Canaveral is better suited to a hopper. The mechanical equipment and cutterhead would be restricted to operations during the late spring and summer, when wave action is less. A shift of the dredging window to accommodate this is viewed favorably by the Resource agencies.

Mechanical equipment

There were considerable discussion and disagreement between the Jacksonville District and industry representatives regarding the potential effectiveness of mechanical equipment. Two previous contracts have been executed with mechanical equipment, both of which had problems. On one occasion, 80 days of work with a mechanical dredge resulted in no net gain in navigable depth as defined by acoustic instruments because of the accumulation of fluff. Industry representatives stated the position that this inefficiency was due to two factors: (a) use of the mechanical equipment during unfavorable wave conditions and (b) dredging only a central portion of the channel, leaving a "plug" of firm material, which prevented the flow of fluff material out of the channel as it was being dredged. Industry claimed that this problem could be solved by using the clamshell during spring and summer and working from the entrance in. Use of an enclosed clam to more efficiently remove the fluff is also a possibility. We found no suggestions on operational techniques for clamshells to minimize turtle take; however, this equipment is thought to have minimum impact on turtles because of the nature of its operation.

Cutterhead

Cutterhead equipment was discussed in the context of using scows with a spider barge to fill them hydraulically. The smallest ocean-certified pipeline dredge is 24 or 27 in. If the material to be removed is a fluid fluff, then this equipment can be effective. One difficulty will be in contracting a sufficient number of scows to keep up with the production of the dredge. At least four may be required. Direct pipeline to the disposal site has problems concerning wave action on the pipeline and safety of recreational craft. Ladder swing speed reduction is one operational method to possibly reduce turtle take with a cutterhead. Depth of burial and cutter rotation were thought to be less important. However, as with mechanical equipment, the cutterhead is thought to have low potential for turtle take because of the nature of its operation.

Hopper

The channel requires dredging now. There is insufficient time to work through contracting procedures to allow mechanical or cutterhead equipment to proceed this summer. Therefore, it appears that the hopper will be used again this fall. There was therefore discussion on how to decrease the take of turtles, focused mainly on an improved exclusion device. A close evaluation of reduced sailing speed (within requirements for steerage) is a possible operational technique to reduce turtle impact with a hopper. An exclusion device consisting of a solid plate plowlike implement was attempted; however, this was damaged during the first few minutes of operation and was removed.

The subgroup suggested the following potential improvements in the design of an exclusion device:

a. Use of a heavy-duty vertical grate as opposed to a solid plate. This would allow sediment to pass through, possibly preventing damage and having less effect on production.

b. Location of the device at a greater distance in front of the draghead suction.

c. Possible use of a material or design which would lessen impact damage to turtles. This design would necessarily ride above the stiffer sediment as opposed to being dragged through it.

d. Use of vertically oriented "tickler chains" suspended well in front of the draghead to cause turtles swimming in the water column to move.

e. Call in a "swat" design team consisting of representatives from the industry, CE, Marine Design Center, and other Corps offices to brainstorm a new design.

Windows

As with turtle behavior, seasonal considerations are also important with respect to dredging operations. Use of mechanical or cutterhead equipment will require shifting the window to late spring and summer. With respect to removal of shoals, summer is the most favored time. Fortunately, these are compatible with the resource agencies' views if an alternate to the present equipment is used. One key point is the burial behavior of the turtles. Dredging should be accomplished at a time when the turtles are not in a lethargic state and are not buried in the sediment. Free-swimming and responsive turtles are much more likely not to be impacted by any dredge type.

Turtle take

The workgroup discussed turtle take and concluded that no take of Ridley's or greens was acceptable. However, some level of incidental take of loggerheads would be acceptable if all reasonable measures to prevent take were implemented. Improved measurement of turtle take with hopper dredges was also discussed. Because of the conditions in the hopper during filling, it is difficult to determine the number of turtles impacted. Screens on the hopper overflow have been used in the past. One suggestion is to conduct a study with marked turtle parts to develop a multiplier for relative retention in the hopper. Another approach is to design a basket sampler for the hopper inflow which would catch all inflowing turtle parts over a short period and then apply a straightforward multiplier for the time of filling. This method would also have potential for measuring take with a cutterhead filling scow.

Recommendations

Recommendations for short-term improvement for the next hopper dredging operation this fall are:

a. Implementation of an improved program to measure turtle take.

b. Redesigning and testing a turtle-exclusion device for the hopper dredge.

Recommendations for long-term solutions are as follows:

a. Conducting additional research into turtle behavior, focusing the efforts only on those aspects of behavior that directly relate to the potential for dredging impacts.

b. Shifting the dredging window to the late spring and summer when turtles are less likely to be hibernating or buried in the sediment.

c. Conducting a detailed evaluation on use of cutterhead or clamshell equipment for the project.

WORKGROUP 3 SUMMARY

James Richardson,* Facilitator

We specified and spent most of our attention on short-term needs. We sensed from the CE members in our group that they wanted some answers very quickly because these contracts are coming out all the time, and what would we do to improve things within the next year or two.

Under short-term needs that can have an immediate effect for the CE for next year's contracts under biological studies, we definitely need to know more about the density patterns of these turtles in the channels, not only in the Canaveral channel but perhaps also up in the St. Marys channel. This has to be done through time and through space within parts of the channel.

We think that the current levels of study are not enough to answer the questions of density pattern and it needs to be improved. We are not sure how much, but we think that the people should be asked to come up with recommended additional coverage needed to look at density patterns. We think that these density patterns need to be very carefully coordinated and characterized according to physical and chemical parameters associated with the density patterns.

There has not been enough done. We need to look at the structure of the channel where these turtles are being found, the slope of the sides of the channel, the amount of sediments, amount of oxygen in the water, and how fast the water is flowing. All of these and many other physical and chemical characteristics that are associated with the density patterns have got to be looked at.

We believe that there is a lot that can be done right now without even going back out in the channel. We think that there is a considerable amount of existing data on these patterns, particularly those that have stayed for several years, persistent density patterns; certain areas of the channel consistently have turtles at higher densities than others. We need to pull all of these data from the different brown boxes in various offices, get them together, and see what these patterns are.

We have a lot of physical parameters already known, a lot of existing cross-sectional drawings of the channel. These things can be done right now

* Institute of Ecology, University of Georgia, Athens, GA.

without any further research in the field.

Then beyond that, we need to expand a number of physical and chemical variables that we are going to gather using sonar and various other methods that will go side by side on further studies on these densities. This area of biological research is predominantly population as a whole.

In addition, another area is behavioral patterns that can be best studied by looking at individual turtles. This has to be done and has to be done very soon.

We need to know more about daily cycles of these turtles. All the questions that we were asked about recommending windows for dredging cannot really be done until more of this is available.

We have to look at feeding patterns. We sense that turtles may be stumbling into this area and staying there. Why are they staying there? Efforts to look at stomach contents have been slowed down because of permitting. We need to let it be known that feeding behavior, feeding patterns are very important as a possible reason why the turtles are present.

We feel that a definitely overlooked area is the presence of these turtles in the mud, not just turtles during cold water but turtles that just choose to bury themselves in the mud as this Ridley did up Long Island for a period of 3 or more days. We have got to find out what these turtles are doing down in the mud.

We need to know particularly what the characterization of this burying is during warmwater periods of the season, mainly because if these turtles are in there during cold water, there is no question dredging should not be in there. We think that not enough has been done with the burying of turtles during warmwater months.

We think that individual turtles need to be followed to study better the relocation experiments that need to be done. How quickly do turtles that are taken out come back, what pattern do they use to come back, what are the seasonal differences in the return of these turtles back to the channel? We are stressing relocation experiments because they appear to be perhaps the best way to deal immediately with the problem of turtles in the channel.

Another area is also related to the fact that these turtles bury themselves in the mud. We need to continue with the behavioral effect of disturbing these turtles that are buried.

We really do not know anything about a lethargic turtle. We need to know what the effect would be of knocking these turtles out of the way with all these removal methods that we are talking about, which are good unless they are causing more damage to the turtles than we were previously aware of.

We looked at economic feasibility studies. We think those are very important, and we need to bring the industry into this problem. It has not been brought in before. We think more of that has to be done. We think the government should look now at the legal limits on permitting these incentives. Where are they permitted to toss out incentives? Where are they going to be blocked by this? The industry needs to be protected for the research and development money they have put into this. How can they recover the investment of their efforts?

The thought of single source bids was tossed out during the first presentation of yesterday. That is pretty good incentive. If it is possible to reward a company by eliminating competition by saying that a particular kind of device that improves the protection of turtles is the only one allowed in the bid, why that is a tremendous incentive.

We think the CE could get more involved in the research by issuing specific contracts and selected test sections. Not the whole thing, but perhaps within one section of this channel, they could open that up only to some sort of mechanical dredge. Looking at the economic feasibility, the weather, windows, all of this, I think they need to do research into that rather than to just toss it out to the industry and say, "You decide how you want to do it." I think the Corps has to look more at the possibilities of using different equipment and do that through the idea of specific sections of the channel out there being used as a research site.

The need to quantify the actual take was mentioned by the other groups. I think that is extremely important. Whatever methods we can use, we have to know exactly what the dredges are doing out there. That is an important thing to do.

All the different dredges need to be checked for how well we monitor the take of turtles, and that is in terms of a per unit effort. It does no good to say a dredge should not be allowed to take three turtles. It has to be how many animals are being impacted, killed, stressed per unit of working time in a particular area. And that is going to add a great deal of confidence as to whether we are on top of the problem or not.

The idea of using carcasses and tracking the turtle parts is a very good one. We discussed the possibility of putting tags, pit tags as they are called, and perhaps having some kind of monitoring system at the mouth of the discharge pipe going into the hopper so that we can measure when a turtle carrying one of the pit tags comes through.

Under long-term needs, we did not rule out the continuing gathering of data concerning population, behavior, growth, and improvement. All of these things are important. We need to keep that going, but it is not the sort of thing that is going to help the CE next year.

We think there are a lot of problems, and we think that if anybody can handle them well, it could be the industry with the proper incentives.

As far as engineering modifications such as deepening channels suggesting slope, they may prove to be extremely valuable. It could be that the side of the slope, angled slope, is what is bringing in the turtles. We cannot deal with that until we do the independent research on the behavior of certain areas.

We think that although the Canaveral channel is the most important thing, we have an opportunity with the King's Bay, St. Marys channel to make sure that turtles are not attracted into that area in the future. It is an opportunity to see a before/after situation that we never had at Canaveral.

Avoidance measures just did not attract a lot of attention in our group. We feel that they are good, and they are interesting; application of sonic explosions and chains and other methods are fine, but they have not been too successful in the past, and with the speed needed for hopper dredges to maintain steerage, we are not convinced that this is a high priority. That does not mean that kind of work should not continue at a slightly less priority.

Under management recommendations, because of the presence of turtles in so many different Districts, we think that the research and development of this area protection of turtles with dredging should be centralized at WES and that they should coordinate all of this effort and work with the industries to develop new ideas.

We think that the best current method is still the removal method, moving in ahead and taking the turtles out using trawls. We think that the efficiency of that method has been perhaps improperly measured in the past, and more effort needs to be done to see just how efficient that method is through use of statistical techniques and varied precise experimental design. We think that this appears to be the quickest way to do it, and it is very easy to expand that method; if one shrimp trawler is not getting the job done, you can bring in two or three. As to how to distribute those so they do not come back in, we are not sure, but we think that is something that can be satisfied and be solved.

We think that exclusion devices to move turtles out of the way of the dragheads is not a particularly fruitful way to go right now. We think any effort underneath the draghead is a complete waste of time. All this talk about setting up openings with selected numbers of inches or screens or anything, all that does is confuse the issue. It makes the environmentalists concerned with the problems being hidden from view. If no turtle is allowed to come through, not only does it hide any impact that may be occurring, but it also messes up the engineers who are trying to get the job done.

Definitely, seasonality has already been done before this meeting. Everybody encourages the continued use of seasonality--when to allow the dredges in there.

Anything you can do, of course, to encourage less impact of equipment such as clamshell or mechanical dredges, if they can work out there, and they do not take turtles, and it is feasible.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were generated by discussions in the three subgroups of the workshop. All groups agreed that more research is needed on the biological behavior of the turtles which relates to potential dredging impacts.

Biological Studies/Information Needed

Biological studies and information needed include the following:

a. All existing data available from studies on the turtles and physical parameters of these channels should be collected and compiled.

b. Physiological/temperature studies are needed to investigate the intent and season of any burial/ "hibernation" activity of the turtles.

c. Daily cycle studies are needed to determine whether and when the turtles are predominantly in the water column or benthic environment.

d. Population/density pattern studies of the turtles need to be done through time and space within the channels (Cape Canaveral and King's Bay).

e. Studies of feeding patterns may help to determine why the turtles are being attracted to the channels.

f. The biological studies need to be very carefully coordinated and characterized according to the associated physical and chemical parameters (i.e. the structure of the channel where these turtles are being found, the slope of the sides of the channel, the amount of sediments, amount of oxygen in the water, and how fast the water is flowing).

g. Use of sonar or other tracking devices needs to be investigated for density/population studies as well as studies on behavioral patterns of individual turtles.

h. If turtles are relocated, experiments need to be conducted to track individuals and gather data on their return to the channel.

i. Studies that investigate dredging impact to turtles other than mortalities are needed.

j. Further studies are needed to determine the turtle's reaction to stimuli such as sonic pingers and other scare techniques.

Dredging Actions/Studies Suggested

Suggested dredging actions and/or studies include the following:

a. A detailed evaluation should be conducted on the use of alternative dragheads and equipment, such as the cutterhead with a spider barge or clamshell, both of which have less potential to take turtles.

b. The present dredging window should be moved from September through November to include June through August to allow use of the alternate methods of dredging with less potential to impinge turtles.

c. Representatives from the dredging industry, WES, Marine Design Center, and other Corps offices should meet to redesign the cattle catcher or other turtle deflector devices. The following are potential improvements in the design of a deflector device:

   (1) Use of a heavy-duty vertical grate as opposed to a solid plate. This would allow sediment to pass through, possibly preventing damage and having less effect on production.

   (2) Location of the device at a greater distance in front of the draghead suction.

   (3) Possible use of a material or design which would lessen impact damage to turtles. This design would ride above the stiffer sediment as opposed to being dragged through it.

   (4) Use of vertically oriented "tickler chains" suspended well in front of the draghead to cause turtles swimming in the water column to move.

d. Techniques should be investigated to determine more accurately the number of turtles being taken. A study should be conducted with marked turtle parts to develop a multiplier for relative retention in the hopper.

e. In addition to more thorough screening techniques, a basket sampler for the hopper inflow should be designed to catch all inflowing turtle parts over a short period and then apply a straightforward multiplier for the time of filling.

f. An administrative review of the provisions in the ESA should be made to allow for mitigation in some instances when compensation for incidental loss is deemed appropriate.

g. Improved methods are needed for temporarily relocating turtles while not jeopardizing the safety or operations of the shrimp trawler or the dredge.

h. Scare devices such as the sonic pingers should be attached to the dredge in combination with the above actions.

Other Conclusions

Additional conclusions include the following:

a. Attempts at permanent relocation of turtles prior to dredging by trawling were largely ineffective because of the hazards to the shrimp trawl and dredge as well as the immediate return of turtles to the channel.

b. Any attempts to exclude the turtles from the channel would be futile because of the large linear configuration of the channel.

c. Previous efforts with avoidance/scare techniques such as sonic pingers and chains have been unsuccessful and do not appear to be a promising technique for the dredges; however, these need to be further investigated or modified.

d. Efforts such as bars, screens, etc., underneath the draghead prevent finding of any killed turtles as well as obstruct dredging operations.

FOLLOW-UP STUDIES AND ACTIONS

The following are the studies and actions which were generated by the conclusions and recommendations of the workshop:

a. The Center for Sea Turtle Research is currently conducting monthly survey studies at King's Bay entrance and Cape Canaveral channel which address some of the biological questions such as population/density patterns, size and sex distribution, and blood chemistry.

b. The WES conducted a series of studies during the 1988 dredging at Cape Canaveral which investigated the recovery of turtle parts with varying buoyancies in the hopper and overflow screens on the *Atchafalaya* and *Dodge Island* dredges. Study conclusions showed that parts heavier than neutrally buoyant are not likely to be seen by turtle observers using the present recovery methods of screening.

c. Representatives from the dredging industry, WES, Marine Design Center, and US Army Engineer District (USAED), Jacksonville, cooperatively developed a rigid turtle deflector device which was tested during the 1988 dredging at Cape Canaveral on the draghead of the *Atchafalaya*. This device was determined to be unsuccessful since it impinged two turtles and broke apart during the first 3 days in use. A flexible, chain deflector device was also tested during this time behind the draghead of the *Dodge Island*. This device shows potential for aiding in reducing turtle mortalities.

d. The hopper inflow was screened on the *Atchafalaya* during the latter phase of the dredging project in Cape Canaveral. This proved to be successful in sampling all material entering the hopper.

e. Mineral Management Service is continuing to study the use of sonic pingers to move turtles away from oil rigs being relocated. Results of this study will help indicate the applicability of this technology to dredges.

f. Alternative dredging equipment is being investigated by the USAED, Jacksonville.

APPENDIX A: SUGGESTED WORKGROUP QUESTIONS

Dredging Operation and Equipment Questions

1. What needs to be known about sea turtles to prevent their take by dredges?

2. Is the use of one type of dredge less likely to take turtles than another?

3. Is the use of one type of dredgehead less likely to take turtles than others?

4. Is there a time of year that is better for dredging? When?

5. Can the operation of the dredge be modified to lessen or eliminate the chances of taking a turtle? (e.g. speed, pattern, etc.)

6. Is there a way to install a turtle excluder device or similar device in the dredge or water jets on the dredge to exclude turtles?

7. Is it feasible to deepen the channel to reduce the frequency of dredging or turtle take?

8. Is there a type of dredge which will not work in Canaveral channel due to cost effectiveness?

9. Can tickler chains be welded in front of the dragheads to temporarily remove the turtles?

10. Could the previously tried cowcatcher be redesigned or reinforced for future use?

11. Is a pipeline dredge feasible? Are there any scours large enough so that the pipeline dredge could be used?

12. Can the dragheads be set lower into the bottom during dredging to get beneath the embedded turtles?

Sea Turtle Biology Questions

1. What needs to be known about sea turtles to minimize dredging effects on turtles?

2. Can the turtles effectively be relocated out of danger from the dredges?

3. Can the turtles be forced to move out of the dredge path?

4. To what stimuli might the turtles respond in efforts to get them to move?

5. What is the best time to dredge in the turtles' annual cycle? When turtles are lethargic? When turtles are nesting? When Kemp's ridleys are absent?

6. What level of turtle take would be considered acceptable?

7. If the US Army Corps of Engineers proves that the three or fewer turtles taken by the dredge is an accurate estimate, is this number reasonable?

8. Can the channel be modified to discourage use by turtles? Is the channel necessary for the turtle?

9. Is one sex or life stage considered more important than the other as far as loss since these may be in the channel at different times of the year?

10. If turtle loss cannot reasonably be avoided, how should the loss be compensated?