

# Dredging impacts on sea turtles in the southeastern USA: A historical review of protection

D. Dickerson<sup>1</sup>, M. Wolters<sup>2</sup>, C. Theriot<sup>3</sup>, C. Slay<sup>4</sup>

**Abstract:** Hopper dredging along the southeastern USA potentially impacts five species of threatened or endangered sea turtles. Documented incidental takes of loggerhead, green, and Kemp's ridley sea turtles have occurred during dredging since 1980 in 38 coastal channels from the Texas-Mexico border through New York. Over the past 24 years, the U.S. Army Corps of Engineers (USACE) and dredging industry have worked to develop protocols, operational methods, and modified dredging equipment to reduce dredging impacts to sea turtles. The success of these protection efforts is illustrated in the reductions in incidental takes compared to the increasing number of dredged channels monitored. Between 1980 and 1981, 71 sea turtle incidental takes were recorded for Canaveral Harbor, Florida alone, whereas 35 takes were collectively recorded from all coastal hopper dredging along the southeastern USA during 2003.

Engineering and biological studies were completed to develop a suite of protective tools to reduce dredging impacts on marine turtles. These investigations have included sea turtle relative-abundance, behavioral, acoustic-detection and dispersal, and dredging equipment development. In addition to gaining valuable data for understanding sea turtle biology, these studies helped to establish environmental windows, draghead modifications, draghead turtle deflectors, and protection protocols such as trawling to relocate sea turtles. The USACE is presently establishing an internet-based database to centralize and archive historical and future data regarding sea turtle impacts from dredging activities for long-term continuity and evaluation of these data. Although the overall impacts to sea turtles from dredging activities is relatively small, the USACE and dredging industry is committed to the continued pursuit of efforts to further reduce dredging impacts on sea turtles.

This paper focuses on the biological aspects regarding dredging impacts on sea turtles and present results from analyses of historical incidental take and dredging data. These data were compiled to provide a measure of success for protection methods and provide better justifications for establishing dredging restrictions.

**Keywords:** sea turtles, endangered species, incidental take, environmental windows, draghead design

<sup>1</sup> Research Biologist, U.S. Army Corps of Engineers, Engineering Research and Development Center, Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS, USA, 39180  
601-634-3772, [dickerd@wes.army.mil](mailto:dickerd@wes.army.mil)

<sup>2</sup> Biologist, Computer Science Corporation, 3909 Halls Ferry Road, Vicksburg, Mississippi, USA, 39180  
601-634-3910, [monica.s.wolters@erdc.usace.army.mil](mailto:monica.s.wolters@erdc.usace.army.mil)

<sup>3</sup> Research Technician, Computer Science Corporation, 3909 Halls Ferry Road, Vicksburg, Mississippi, USA, 39180  
601-634-3689, [craig.t.theriot@erdc.usace.army.mil](mailto:craig.t.theriot@erdc.usace.army.mil)

<sup>4</sup> President and Observer Coordinator, Coastwise Consulting, 173 Virginia Avenue, Athens, GA 30601  
706-543-6859, [cslay@worldnet.att.net](mailto:cslay@worldnet.att.net)

## INTRODUCTION

Five species of threatened or endangered sea turtles are known to inhabit channels along the southeastern United States coastline and are potentially entrained during hopper dredging of these channels. A total of 508 incidental takes of sea turtles by hopper dredges have occurred from 1980 through 2003. Dramatic reductions in sea turtle entrainment have occurred as a result of dredging and management alternatives implemented. This paper examines the history of issues concerning dredging impacts on sea turtles in these channels, research efforts to identify methods to minimize impacts, as well as dredging and sea turtle management alternatives implemented to reduce entrainment of sea turtles.

### Endangered Species Act of 1973

The purpose of the Endangered Species Act (ESA) of 1973 is “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” (USFWS 2004). 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 intends 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. In the case of channel dredging throughout the southeastern United States, endangered and threatened sea turtles are potentially impacted by hopper dredging. Therefore, to be in compliance with the intention of the Act, the U.S. Army Corps of Engineers (USACE) must consider all alternatives and protective measures to conserve these species by minimizing or eliminating sea turtle mortalities during dredging operations. The National Marine Fisheries Service (NMFS) is responsible for administering the ESA for all Federal actions which may impact endangered and threatened species at sea such as sea turtles. The NMFS performs an advisory function to identify and help resolve conflicts between the actions of the Federal agencies, such as the USACE, and listed species, as well as their critical habitat.

Under the consultation process set forth by Section 7 (a)(2) of the ESA, the USACE prepares a Biological Assessment which describes the proposed dredging activity, identifies any endangered or threatened species potentially impacted by the project, and determines likely impacts to any listed species. The NMFS must formulate a Biological Opinion as to whether or not the activity “is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.” If jeopardy or adverse modification is determined, the NMFS proposes reasonable and prudent alternatives to reduce negative impacts to the listed species. If there are no reasonable and prudent alternatives known for the proposed action or if the USACE cannot implement these recommendations, the proposed dredging activity cannot proceed without special provisions of an exemption. The reasonable and prudent alternatives for dredging operations are based on available scientific and commercial data; however, these supporting data are frequently minimal or completely lacking.

The NMFS also provides an Incidental Take Statement with the Biological Opinion when the proposed dredging activity may incidentally take individuals of a listed species but not jeopardize the continued existence of the species. This is not to be misinterpreted as designating an acceptable level of take during a given activity or that the NMFS condones the take of any threatened or endangered species. The Incidental Take Statement only exempts the USACE and its contractors from prosecution if an endangered or threatened species is taken, assuming that all possible steps have been implemented to minimize the impacts of dredging activities to the listed species. Table 1 provides the current take numbers allowed for sea turtles and sturgeon by USACE geographic region in the southeastern United States. Listed sturgeon species include Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and shortnose sturgeon (*Acipenser brevirostrum*). After consulting the available data on known dredging impacts as well as biological data for sea turtles and sturgeon, the NMFS worked with the USACE to establish incidental take numbers that should not jeopardize these species.

**Table 1. Annual incidental take allowed (injury or mortality) by NMFS Biological Opinion**

USACE Region	Biological Opinion	Loggerheads	Kemps	Greens	Hawksbills	Sturgeon (Gulf and Shortnose)
North Atlantic Division (North of NC)	2003	Varies by channel and cubic yards dredged				
South Atlantic Division (NC thru FL)	25 Sep 1997	35	7	7	2	5 (Shortnose)
Jacksonville District (FL West Coast)	19 Nov 2003	5	3	3	1	1 (Gulf)
Mobile District (North Gulf of Mexico)	19 Nov 2003	5	3	3	1	2 (Gulf)
New Orleans District (N. Gulf of Mexico)	19 Nov 2003	15	7	3	1	1 (Gulf)
Galveston District (West Gulf of Mexico)	19 Nov 2003	15	7	5	1	NA
Combined Gulf of Mexico	19 Nov 2003	40	20	14	4	4 (Gulf)

## Sea Turtles

The sea turtle species primarily affected by dredging are loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempi*), although, hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coriacea*) are also potentially vulnerable (National Research Council 1990). Kemp's ridley, leatherbacks, and hawksbills are listed by the ESA as endangered throughout their ranges; green turtles are endangered in Florida and are threatened in all other locations; loggerheads are listed as threatened throughout their entire range. In the United States, sea turtles occur in the Gulf of Mexico from Texas to Florida, Puerto Rico and the Virgin Islands; in the western Atlantic from Florida to Massachusetts; and in the Pacific along California, Hawaii, and U.S. territories (Lutz and Musick 1997). The greatest portion of a sea turtle's life history is spent in ocean and estuarine waters. Only a small portion of their life history is spent on land where the female digs a nest and lays her eggs within coastal sandy beaches. Very little is known about the biology and life history of sea turtles associated with coastal channels along the United States. Many management decisions concerning potential dredging impacts to sea turtles must, therefore, be made based on anecdotal or "best guess" information without defensible scientific data.

## Monitoring for Sea Turtle Incidental Take

Monitoring for incidental takes of sea turtles began as soon as the earliest incidents were reported from the hopper dredging activities at Canaveral Harbor, Florida in 1980 (Rudloe 1981, Joyce 1982). In addition to hopper dredges, monitoring has been done periodically over the past 24 years on clamshell and cutterhead projects; however, no incidental takes of sea turtles have been reported from dredges other than from hopper dredges which use trailing suction dragheads. NMFS approved personnel are contracted to serve as endangered species observers. Multiple observers typically work during a single dredging project, working 8 to 12 hour shifts to cover the 24-hour monitoring. Historically, the percent coverage of monitoring required by NMFS was highly variable (Dickerson et al. 1991).

Because the material being pumped into the hopper dredge is difficult to visually monitor, screening has been utilized to sample the dredged material to recover turtle specimens. Various screening configurations of skimmers, overboard overflows, and inflow pipes have been used. The vast differences in dredges preclude a standard design for screening configurations. Differences in the requirements by the NMFS from 1980 to 2003 for the amount of dredged material to be screened and monitored have also led to the extreme variations in screening configurations between dredging projects throughout the southeastern coastal United States. Turtle take totals based strictly on overflow and skimmer screen collections may be low estimates because these screens primarily are limited to collecting floating material which may not be typical for freshly killed turtle specimens. Screening of material coming into the hopper through the inflow pipes provides far better assessments and sampling for turtle specimens. However, due to the extreme force of this material through the screening, it is likely that some specimens may go undetected by the observers. The variability of the internal discharge piping designs between the dredges of the hopper fleet inhibits a generic design to screen inflows and has presented a challenge to create workable designs for each dredge.

Although the screening design may vary between dredges, efforts to screen dredged material are now more thorough and consistent between dredges and dredging projects. This allows more confidence when evaluating incidental take numbers of sea turtles from recent and current dredging projects. Caution should be used when

comparing current incidental take numbers with earlier years. Earlier years are assumed to be underestimates in reported values because of inconsistent monitoring methods. Number of incidents reported should also be evaluated with reference to the number of channels or projects being monitored by endangered species monitors.

### Scope and Range of Dredging Impacts

Over the past 24 years, an increasing number of channels and dredging projects have been included in the monitoring requirements for sea turtle incidental takes. Currently, there are more than 50 channels or projects in the southeastern United States that include endangered species monitoring as illustrated in Figure 1. Of these locations, 38 have had documented incidental takes of sea turtles. These issues involve 11 USACE Districts, 4 USACE Divisions, and all hopper dredges operating along the coastal southeastern United States from the Texas-Mexico border through New York.



**Fig. 1. USACE hopper dredging projects with sea turtle monitoring**

From 1980 through 1985, Canaveral Harbor was the only channel monitored for sea turtle incidents. From 1986 through 1990, Kings Bay, Georgia was a second channel monitored. Four additional channels, (Savannah, Georgia; Brunswick, Georgia; Charleston, South Carolina; and Wilmington, North Carolina) were required to have monitoring in 1991, whereas, the remaining South Atlantic channels were included as of 1992. The North Atlantic channels above North Carolina began monitoring in 1994 and many of the channels throughout the Gulf of Mexico began monitoring in 1995. All localities along the coastal southeastern United States with hopper dredging had comparable methodologies for sea turtle monitoring as of 2002. The differences in monitoring requirements over the past 24 years is a reflection of the differences in Biological Opinions from separate NMFS offices for distinct geographic regions as well as changes in the understanding of sea turtle biology and dredging impacts throughout the southeastern United States.

## **CORPS RESPONSE TO SEA TURTLE ISSUES**

### **Early Years**

In May 1981, a Sea Turtle/Dredging Task Force was formally established by the Jacksonville District Corps of Engineers to address the conflicting issues of sea turtle incidental takes by dredges and maintaining a navigable channel at Canaveral Harbor for commercial interests and national defense (Berry 1990). This task force was comprised of representatives from the NMFS, U.S. Fish and Wildlife Service, Florida Department of Natural Resources, U.S. Navy, and the USACE. As a result of recommendations generated and implemented by the task force, the number of documented incidental takes of sea turtles was reduced throughout the 1980's. In May 1988, a National Sea Turtle/Dredging Workshop brought together technical sea turtle and dredging experts to examine the problems and potential solutions more closely (Dickerson and Nelson 1990). Specific measures recommended by the Task Force and the workshop participants provided the concept foundations for dredging equipment alternatives and modifications that eventually led to the USACE Sea Turtle Research Program (STRP).

### **USACE Sea Turtle Research Program (STRP)**

The STRP was a 2-year effort established in 1991 in response to the critical need for immediate and long-term dredging alternatives and protective measures to minimize the impact of USACE hopper dredging on sea turtles (Dickerson et al. 1993, USAE WES 1997). A team of technical experts from the USACE Engineering Research and Development Center at Waterways Experiment Station was assembled to develop and implement this multifaceted program. The STRP was divided into two interrelated approaches: (a) a biological approach, and (b) an engineering approach. The biological approach consisted of two distinct research tasks: (a) relative-abundance investigations, and (b) behavioral studies. The biological approach employed spatial and temporal surveys and telemetry studies that provided data to establish indices of sea turtle abundance and behavioral patterns in selected channels. The engineering approach consisted of four distinct research tasks (a) acoustic-detection investigations, (b) bio-acoustic studies, (c) acoustic-dispersal evaluations, and (d) dredging equipment development and evaluation. The engineering approach made use of physical model studies, engineering and structural analyses, acoustics, and field demonstrations to develop sea turtle friendly dredging equipment alternatives.

The relative-abundance investigations determined indices of relative abundance for the various sea turtle species at six southeast Atlantic harbor entrance channels maintained by hopper dredges: (a) Canaveral Harbor, Florida, (b) Kings Bay, Georgia, (c) Brunswick Harbor, Georgia, (d) Savannah Harbor, Georgia, (e) Charleston Harbor, South Carolina, and (f) Morehead City Harbor, North Carolina (Dickerson et al. 1995). This study was accomplished through trawling the channels in a set pattern with standardized trawling equipment over a specified time period. As turtles were captured in the trawl, they were brought aboard the trawling vessel, examined, measured, tagged for identification and released. Analyses included capture and recapture rates per unit time and per unit area for each channel as well as critical water temperature for sea turtle occurrence.

Behavioral studies monitored movement of sea turtles over time and distance with biotelemetry techniques in the vicinity of four southeast Atlantic channels maintained by hopper dredges; (a) Canaveral Harbor, (b) Kings Bay, (c) Savannah Harbor, and (d) Charleston Harbor (USAE WES 1997). Biotelemetry is the process of attaching radio, sonic, and/or satellite transmitters to the shell of sea turtles and documenting their behavior through tracking their movement patterns.

Acoustic-detection investigations evaluated hydroacoustic technologies as potential methods to faster and/or more reliably conduct quantitative sea turtle surveys in channels (Kasul and Dickerson 1993). Mine-detection and fish-locating technologies were pursued to determine hydroacoustic signatures of sea turtles submerged in a

navigation channel. Although hydroacoustic signatures for sea turtles were identified, no hydroacoustic technologies were identified for practical application.

Bio-acoustic studies were conducted to determine the acoustic thresholds, frequency range, and auditory behavior of both sea turtles and manatees (marine mammals which occupy the same coastal waters and may be impacted by sea turtle dispersal techniques) (USAE WES 1997). Controlled tests on live loggerhead sea turtles at the Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia established acoustic thresholds and frequency range baseline information for sea turtle acoustic dispersal studies (Moein 1994). Controlled tests on live West Indian manatees by the Manatee Research Center, Florida Atlantic University, Boca Raton, Florida (tests conducted at Lowry Park Zoo, Tampa, Florida), established acoustic thresholds and auditory behavior of manatees.

Acoustic-dispersal studies evaluated acoustic techniques to safely disperse sea turtles from the vicinity of hopper dredge dragheads (USAE WES 1997). Controlled field tests using live sea turtles and air- and water guns meeting turtle auditory range requirements were conducted at the Virginia Institute of Marine Science to determine sea turtle behavioral responses to these acoustic devices. These same devices were tested aboard the Corps hopper dredge *McFarland* to determine the operational and logistical constraints with such equipment.

As part of the alternative dredging equipment development and evaluation component of the STRP, a series of sea turtle deflectors were developed and evaluated with physical model testing (Banks and Alexander 1994). Three deflector configurations using a California style draghead on the dredge *McFarland* were further developed for field testing with concrete mock turtles in the clear water environment of Fort Pierce, Florida. One deflector design was finally selected for testing under actual prototype dredging operations at Canaveral Harbor (Nelson and Shafer 1996).

### **Current Efforts**

Although significant reduction in incidental takes of sea turtles have occurred from the many protective measures implemented, the USACE and dredging industry are committed to the continued pursuit of efforts to further reduce dredging impacts on sea turtles. Currently the USACE is assimilating and evaluating the historical data in an effort to document trends in incidental takes and establish an internet based archival system for sea turtle and dredging data. Efforts are underway to improve training for and communication between all parties involved with these issues. Systems are being implemented to provide more automated recording and retrieval of dredging and endangered species observer data during dredging projects. Designs and studies are proposed to refine draghead and deflector equipment to further reduce sea turtle takes. Clausner et al. (2004) discusses in more detail the development of the alternative draghead and deflector equipment as well as current and proposed efforts by the USACE for sea turtle protection.

## **METHODS TO MINIMIZE IMPACTS TO SEA TURTLES**

### **Pre-dredging Assessments of Turtles**

Assessments of the relative abundance or location of sea turtles within a channel prior to a dredging operation is valuable for timing of a dredging project but not always practical or possible. Although numerous efforts have been attempted, current hydroacoustic technologies are not available to effectively and practically survey for sea turtles in these channels. Sea turtle relative abundance is greatly reduced when water temperature is below 16°C, although, a sea turtle take was recorded in Brunswick during 2003 at 13.9°C (Dickerson et al. 1995, USACE Savannah District 2003 dredging data). Monitoring water temperature prior to dredging may provide some insight into sea turtle occurrence within the channel and identify turtle safe periods for dredging. Pre-dredging surveys using trawling techniques can also provide assessments of relative abundance of sea turtles, however, this method can be costly and logistically difficult.

### **Environmental Windows**

To minimize sea turtle incidental takes by dredges, environmental windows were established which restrict dredging to periods when turtles are least abundant or least likely to be affected by dredging. The environmental windows for turtle safe dredging have targeted the winter months since sea turtle abundance is dramatically reduced at water temperatures below 16°C and typically absent during temperatures below 12°C. The environmental window for all hopper dredging within the southeastern United States has evolved over time but is now typically 1 Dec through 31 March. Slight alterations in this timing may occur depending on the specific channel or coastal region of the United States. This is due to differences in spatial and temporal

occurrence of sea turtles throughout the coastal channels from temperature variations between regions. These environmental windows are designated in the Biological Opinions by the NMFS after considering the available biological and dredging data. Therefore, continued efforts are needed to collect the necessary biological and dredging data to support or refine the environmental windows for dredging activities. Restricting all hopper dredging to this environmental window creates extreme scheduling difficulties and potential safety issues for the dredge crew because dredging is concentrated during the winter when sea conditions are more severe.

### **Dredge Type**

Incidental takes of sea turtles have only been documented from hopper dredge operations that use trailing suction dragheads. Thus far, no incidental takes of sea turtles have been reported from clamshell, pipeline cutterhead, or other types of dredges operating in southeastern coastal channels. Operational differences between these dredge types contribute to the differences in potential impacts to sea turtles. The relatively slow dredging motion of clamshell and pipeline dredges present minimal risk for sea turtle takes but they are less likely to provide dredging to the required depths in a timely fashion and at a cost comparable to hopper dredging methods. These slower dredge types are normally restricted to wave climates of less than 3 feet, therefore, hopper dredges are more frequently used for coastal channel projects along the United States.

Due to the high numbers of sea turtles year round and the potential for unacceptable numbers of takes, hopper dredging has not been allowed in Canaveral Harbor since 1992 except during temporary emergency exemptions. Dredging of this channel has since been accomplished, at a substantial increase in cost, by means of mechanical or cutterhead dredging with no documented sea turtle takes. No restrictions related to sea turtles are imposed on channel dredging operations if mechanical or cutterhead dredge types are used with the exception of beach disposal restrictions during nesting season.

### **Draghead Type**

Prior to 1980, hopper dredges typically used the IHC draghead that was positioned more upright with its opening acting like a scoop (Dickerson et al. 1990). During the 1981 dredging activities in Canaveral Harbor, the IHC draghead was changed to a California style draghead that sits flatter in the sediment. This change in the type of draghead used resulted in immediate reductions in sea turtle takes. There were a total of 71 turtle takes during the 1980 through 1981 Canaveral Harbor project which reduced to 6 turtle takes during the second Canaveral project in 1981 with the California style draghead (Studt 1987).

The size of the intakes on the underside of the draghead was limited to 300 mm or smaller openings from 1980 to 1987. However, it was determined that reducing the size of these openings did not reduce turtle mortalities and restricted the successful recovery of specimens by observers to adequately assess the number of turtle takes. Water intake openings on top of the draghead have been screened or covered since 1988 to prevent entrainment of smaller turtles from the water column.

### **Deflectors for Dragheads**

A series of “cow-catcher” type turtle deflectors have been installed on dragheads and tested throughout the history of dredging issues concerning sea turtle takes. The first deflectors were tested on the USACE dredge *McFarland* in 1981 and was constructed using 12.5 mm steel plate in a V-shape and attached in front of the draghead with 50 mm anchor chain (Dickerson et al. 1990). The deflector was designed to pivot with the movement of the draghead but the deflector was crushed in a matter of minutes when tested.

In 1988, two additional deflectors concepts were tested (Nelson et al. 1989). One design was for a rigid deflector made of a series of parallel steel plates welded to the front of the draghead to form a V-shaped pattern. Twelve-mm plates were spaced 250 mm apart and varied in height from 0.61 to 1.31 m. The bottom of the plates was 150 mm below the bottom horizontal plane of the draghead when dredging. This rigid deflector was quickly discontinued after 3 days of use due to damage or complete loss of plates as well as the deaths of 2 turtles impinged between the deflector plates.

The second design tested in 1988 was constructed of flexible 12.5 mm chain webbing attached forward of the draghead in a V-shaped configuration to the dragarm and draghead. A solid steel 300 mm diameter ball was installed at the lower forward end of the “V” to help the chain webbing maintain its deflector shape. Although initial tests of this flexible design showed some promise, actual implementation of this design during dredging operations proved to require constant repairs to maintain the deflector in working condition.

Between 1991 and 1992, various configurations of flexible deflectors with chain and pipes were used with limited success (Banks and Alexander 1994). The major difficulties with these types of deflectors were due to the intense maintenance required and the lack of knowledge at that time about their effectiveness for deflecting turtles.

The dredging equipment studies of the STRP developed and field tested three draghead configurations aboard the *McFarland* during June 1993 in Ft. Pierce, Florida; (a) California-style draghead unmodified, (b) California-style draghead with a chain deflector, and (c) California-style draghead with a rigid deflector (Banks and Alexander 1994). These field tests demonstrated that the rigid deflector was effective in deflecting mock concrete sea turtles with no adverse impact on dredge production. The California style draghead with a rigid deflector was further evaluated under actual prototype dredging operations on the *McFarland* at Canaveral Harbor, Florida in September 1993.

The NMFS has included the rigid deflector draghead design as part of the reasonable and prudent dredging alternatives in the Biological Opinions for dredging projects throughout the southeastern United States since 1993. Sea turtle entrainment rates have been dramatically reduced when the rigid deflectors are used and deployed correctly. However, if these deflectors are not operated so that they maintain constant contact with the sediment, they can actually act as a trap for sea turtles instead of a deflector. Information regarding specifications for this rigid deflector and draghead operations can be found at <http://www.saj.usace.army.mil/pd/turtle.htm>.

### **Relocation of Turtles**

Efforts to use shrimp trawlers to sweep nets ahead of the dredge to clear the channel of turtles and relocate the turtles away from the path of the dredge were first used in 1980 at Canaveral Harbor (Rudloe 1981). A total of 1,250 turtles was captured by trawling over a 4-month period and relocated approximately 5 miles down the coast away from dredging activities. This particular effort in Canaveral was considered impractical and ineffective due to several factors in addition to its high cost of \$300,000 (currency in U.S dollars). Large numbers of sea turtles were present in Canaveral Harbor during that year and many of the relocated turtles immediately returned to the channel.

Relocation operations conducted during June 1991 at Brunswick Harbor relocated 70 turtles approximately 6 to 12 nm out of the channel (Dickerson et al. 1995). Only one was recaptured. A total of 27 turtles were relocated during June 1991 at Savannah Harbor and none were recaptured. Relocation operations are generally not begun until the latter portion of a dredging project which makes assessment of the effectiveness of this technique difficult. However, during the first 66 days of the dredging project at Brunswick Harbor, 21 turtle takes were documented prior to the initiation of relocation efforts while only one entrained turtle was documented in the 25 days thereafter. Similarly, 17 turtle takes were documented during the first 10 days of the dredging project at Savannah Harbor prior to the initiation of relocation efforts and none were reported in the 14 days when relocation trawling was used. Numerous examples similar to these can also be found throughout hopper dredging projects where trawling has been used to relocate turtles since 1991.

This method of sea turtle protection is typically held as a last resort due to the high financial costs, logistical difficulties, and safety risks required to deploy such efforts. These vessels can cost over \$5,000 per day to operate, specialized nets run a minimum of \$9,000 per project, and personnel usually cost over \$500 per person per day. A slower moving trawler frequently cannot work safely in front of the moving dredge; therefore, trawling is usually conducted away from danger far ahead of the dredge and other channel traffic. The trawl nets frequently bog down with large clay balls, bycatch, and other trash and debris in the channel causing the trawler to spin around and subject the vessel to damage, collision with the dredge or other vessels, or complete loss of equipment. Trawling vessels cannot operate effectively or safely in rough seas or heavy storms, therefore, relocation efforts are not possible in all weather conditions. Specifications for trawling equipment and relocation methodology can be found at <http://www.saj.usace.army.mil/pd/trawl.htm>.

### **Dispersal of Turtles**

Many concepts have been suggested and tested to “startle” and disperse sea turtles away from the path of a draghead. These concepts have included sonic pingers, air cannons, tickler chains, bubblers, and electricity (USAE WES 1997). All of these concepts, with the exception of electricity, have been tested either in a controlled setting with sea turtles or deployed during actual dredging activities. No method has been found to successfully and consistently disperse sea turtles for this application. These tests have found that sea turtles are unpredictable in the direction of their response to the stimuli. Some turtles respond by moving downward toward the channel bottom, defeating the purpose of the dispersal method. As found during the air cannon and



sonic pinger tests, turtles habituated to the disturbance and a few turtles actually rested on the equipment during testing. Air cannons and sonic pingers attached to actual dragheads and tested during dredging operations created significant reverberations throughout the vessel and disruptive annoyances for the dredge crew. Tickler chains and other such dispersal devices attached to the draghead are difficult to maintain and have not been demonstrated to be effective with sea turtles.

## SUMMARY OF SEA TURTLE INCIDENTAL TAKES

A total of 508 incidental takes of sea turtles from hopper dredging operations have been documented between 1980 through 2003 from 38 locations throughout the southeastern United States. These takes include 360 loggerheads, 50 greens, 37 Kemp's ridley, and 61 unidentified turtle species with 363 occurring from the South Atlantic (North Carolina through south Florida), 54 from the North Atlantic (region north of North Carolina), and 91 from the Gulf of Mexico (Figures 2 and 3). When turtle takes are evaluated by both species and regions, the South Atlantic region had higher numbers of takes for all species but the locations in the Gulf of Mexico along the western coast of Florida had few, if any, documented takes (Figure 4).

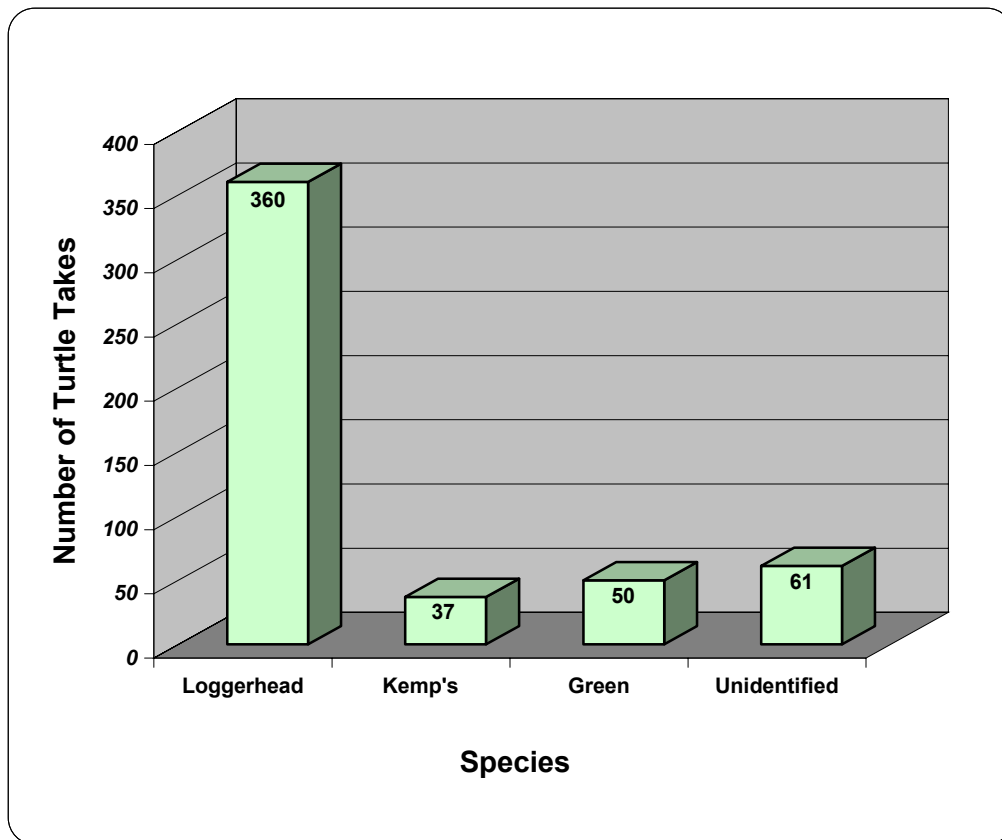


Fig. 2. Total sea turtle takes by species 1980-2003

Due to the extreme inconsistencies in percent monitoring, screening configurations, number of projects monitored, and other methods for quantifying incidental takes, caution should be taken when interpreting the fluctuations in the annual incidental take data (Figure 5). However, when these data are presented with reference to the increasing number of projects monitored annually, it is easier to illustrate the notable reductions in takes. Figure 6 illustrates the catch per unit effort (CPUE) assessment of sea turtle incidents per monitored dredging projects. Prior to 1992, the conservative figures ranged from 3 to 39 sea turtle incidents per project, whereas, starting in 1992, these numbers ranged from 0.25 to 1.87 turtle takes per project. It was in 1992 that the results and products from the STRP were starting to be implemented through turtle deflectors, relocation trawling, and dredging windows.

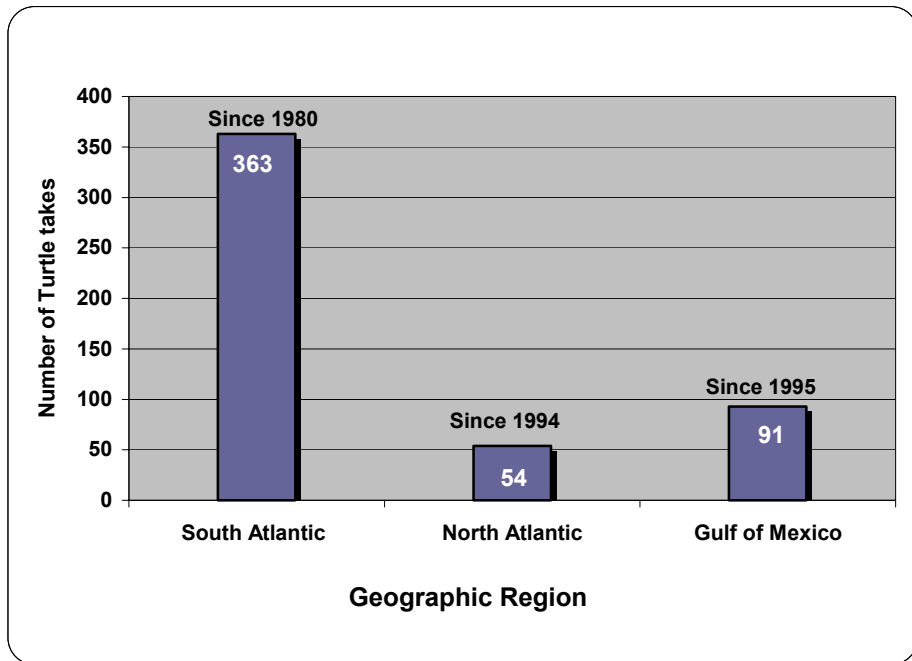


Fig. 3. Total sea turtle takes by United States geographic region 1980-2003

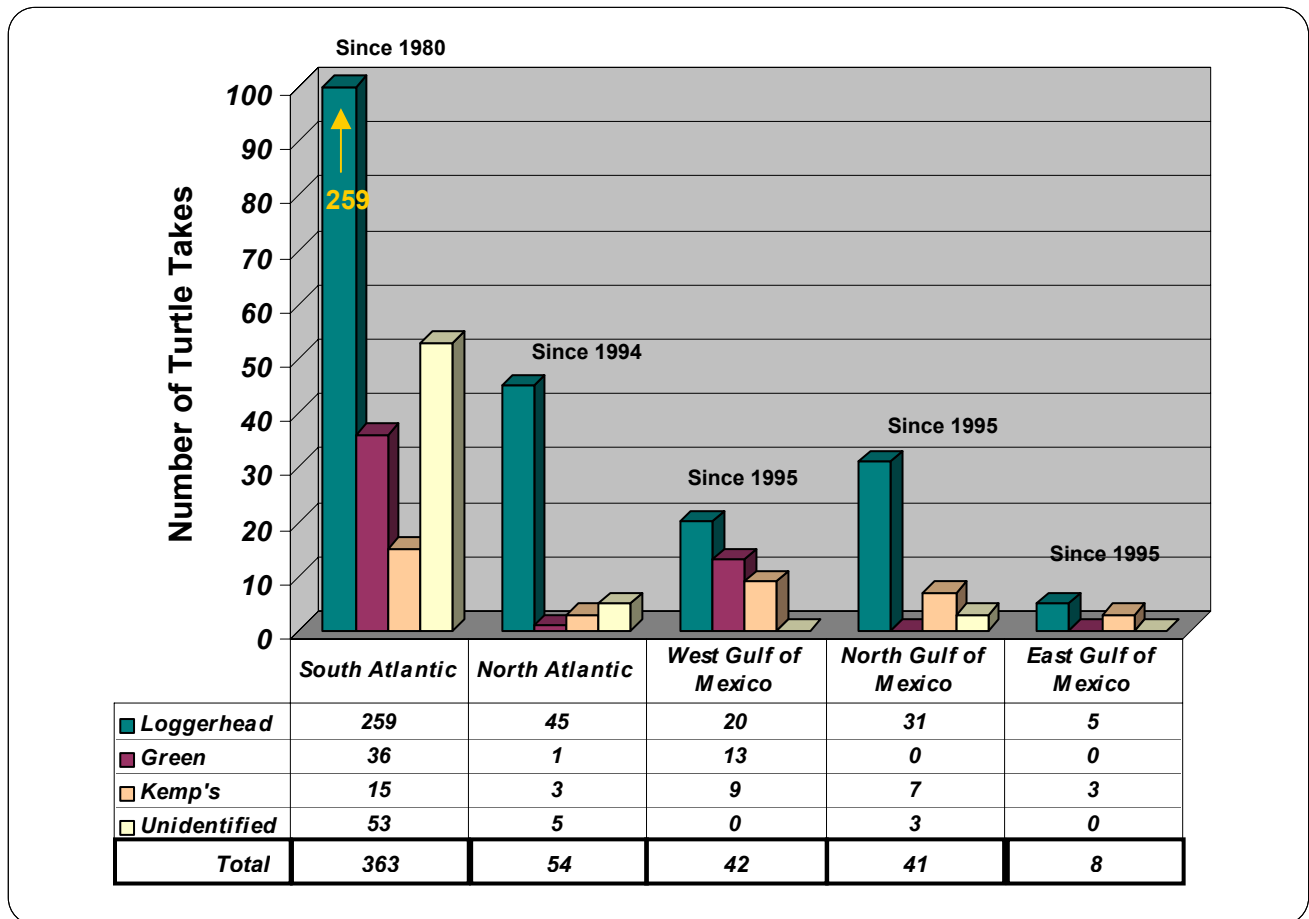


Fig. 4. Sea turtle takes by species and geographic regions 1980-2003

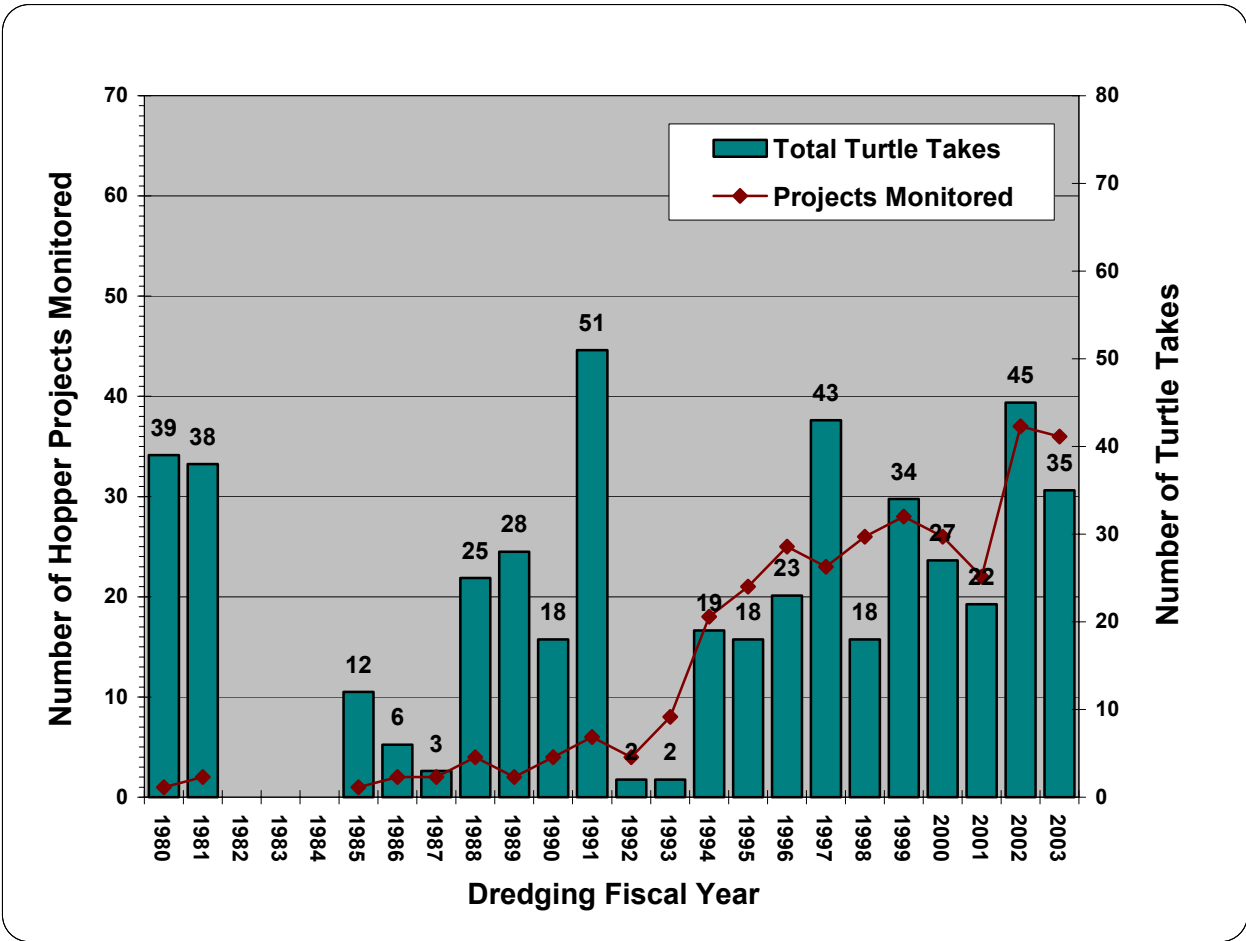


Fig. 5. Annual sea turtle takes and number of hopper dredging projects monitored

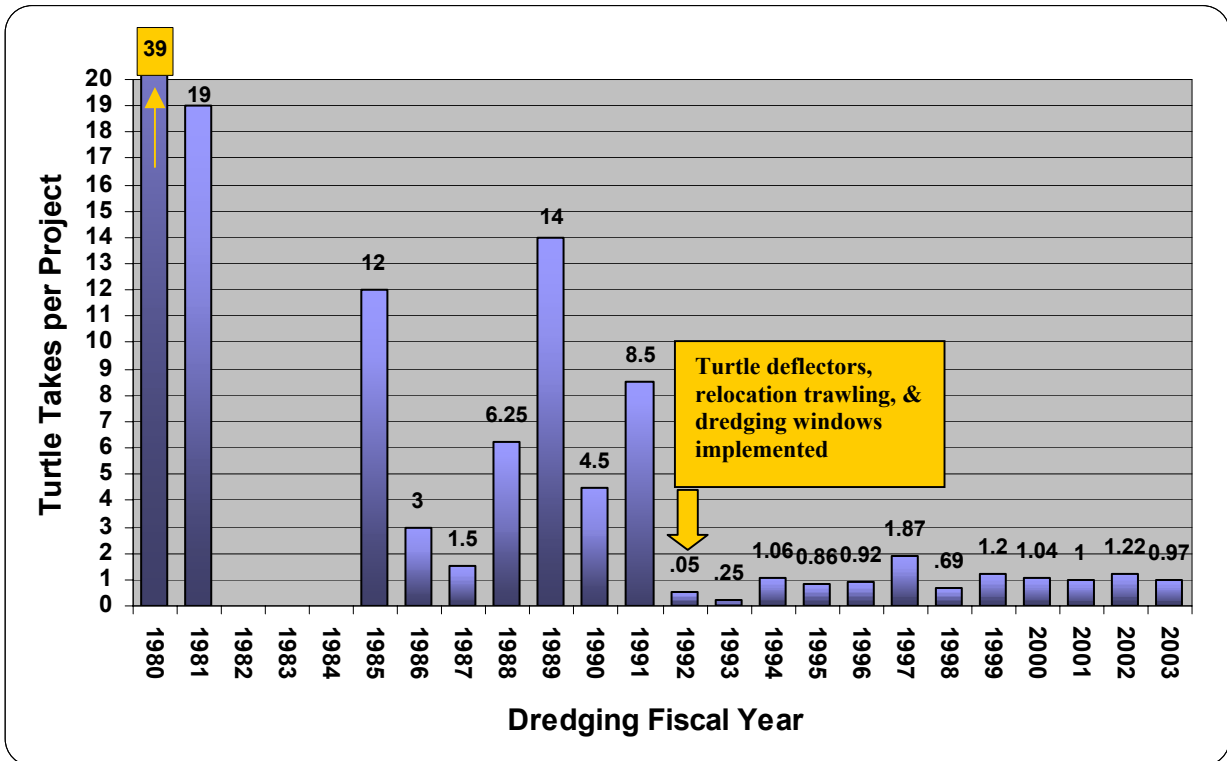


Fig. 6. Catch per unit effort (CPUE) for sea turtle takes per dredging projects with sea turtle monitoring

## CONCLUSION

Incidental takes of sea turtles, the issues involved with protection of these species, and compliance with the ESA impact one third of the USACE Districts and all coastal hopper dredging operations along the southeastern United States. As a result, large investments of time and financial resources have been devoted to reducing turtle takes by hopper dredging since 1980. Great strides have been made towards this goal through a suite of protective efforts implemented. Efforts continue to identify additional methods to reduce sea turtle takes, better document sea turtle biology and dredging impacts in hopper-dredged channels, and work with NMFS to increase dredging options while minimizing impacts to sea turtles.

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