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**CENTER FOR DOLPHIN BIOLOGY, HEALTH,  
AND CONSERVATION EDUCATION**

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**Sarasota Dolphin Research Program -- A Collaborative Program Involving  
The Chicago Zoological Society and Mote Marine Laboratory**

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**Abstract**

Bottlenose dolphins (*Tursiops truncatus*) are among the cetacean species most impacted by human activities in the coastal waters of the United States and around the world. National Marine Fisheries Service (NMFS) management of cetacean stocks and the threats they face requires knowledge of the nature and scope of the threats, and cumulative impacts when considered along with natural sources of mortality and serious injury. Evaluation of the nature and scope of the natural and man-made threats to bottlenose dolphins requires a detailed understanding of the species. The Chicago Zoological Society's Sarasota Dolphin Research Program (SDRP) is uniquely qualified to investigate the biology, behavior, ecology, health, and impacts of humans on inshore bottlenose dolphins along the central west coast of Florida through its research over more than 38 years on the multi-generational resident dolphins of Sarasota Bay, Florida. Research was conducted by SDRP staff and students, in partnership with collaborating specialists from around the world. Our approach involved longitudinal study of individual dolphins through their lives, primarily by means of photographic identification surveys, capture-release for sampling and measurements, biopsy dart sampling, and focal animal behavioral observations. Research under the Project was performed during July 2001 through June 2008, and consisted of 33 Jobs grouped within six major categories: 1) Population Structure, Dynamics, and Stock Identification, 2) Health Assessment and Biomarkers of Environmental Contaminants and their Effects, 3) Ecological Relationships, 4) Human Interactions, 5) Graduate Student Research, and 6) Dissemination of Information. The Project resulted in, or contributed to, more than 60 published peer-reviewed scientific journal articles or technical reports, with another 11 currently "in press" and ten more submitted to journals and undergoing peer review.

The Project has contributed to graduate student research efforts through field work opportunities, samples, or guidance from program staff, resulting in the completion of eight doctoral dissertations, with four more in progress, and ten Master's theses, with one more in progress. The research team made more than 150 scientific presentations, and more than 60 public and university lectures on topics related to the Project. The long-term natural laboratory situation of Sarasota Bay provides unparalleled opportunities to obtain information of importance to the management of inshore bottlenose dolphins.

## Executive Summary

Bottlenose dolphins (*Tursiops truncatus*) are among the cetacean species most impacted by human activities in the coastal waters of the United States and around the world. They are exposed to a number of activities that have the potential to adversely impact their survival and reproduction. National Marine Fisheries Service (NMFS) management of cetacean stocks and the threats they face requires knowledge of the nature and scope of the threats, and cumulative impacts when considered along with natural sources of mortality and serious injury. Evaluation of the nature and scope of the natural and man-made threats to bottlenose dolphins requires a detailed understanding of the species. The Chicago Zoological Society's Sarasota Dolphin Research Program (SDRP), based at Mote Marine Laboratory, is uniquely qualified to investigate the biology, behavior, ecology, health, and impacts of humans on inshore bottlenose dolphins along the central west coast of Florida, and to assist the NMFS to obtain requisite information for management. Research over more than 38 years on the multi-generational resident dolphins of Sarasota Bay has established the bay as an unparalleled natural laboratory situation. The award from NMFS for the Center for Dolphin Biology, Health, and Conservation Education (the Project) enhanced the capacity of the SDRP to conduct research of importance to NMFS, taking advantage of the natural laboratory to address issues of conservation relevance.

Research was conducted by SDRP staff and students, in partnership with collaborating specialists from around the world. The basic research approach involved longitudinal study of individual dolphins through their lives, primarily by means of photographic identification surveys, capture-release for sampling and measurements, biopsy dart sampling, and focal animal behavioral observations. Research under the Project was performed during July 2001 through June 2008, and consisted of 33 Jobs grouped within six major categories: 1) Population Structure, Dynamics, and Stock Identification, 2) Health Assessment and Biomarkers of Environmental Contaminants and their Effects, 3) Ecological Relationships, 4) Human Interactions, 5) Graduate Student Research, and 6) Dissemination of Information.

Ongoing monitoring of the resident Sarasota Bay dolphin community provided the basis for identification of inter-annual trends in abundance and vital rates, leading to examination of the potential roles of environmental factors such as red tide blooms and fishery management as correlates of changes. Integrated research efforts in Sarasota Bay and surrounding waters provided validation of the approach of using a combination of ranging patterns, social association patterns, genetics, and stable isotopes to identify biologically-meaningful population units (communities). Core underpinnings of social structure within these communities were examined, including identifying the acoustic dimension for defining groups, the use of signature whistles as individual identifiers and contact calls, factors influencing survival of juveniles, and

delineation of ecological and reproductive factors involved in the development of the unique strong male pair bonds that characterize the adult lives of most males.

Research continued with Project support into understanding factors influencing the health of the resident dolphin community as well as defining ranges of health and body condition parameters as reference values for comparisons with other population units. Dolphin tissues were examined for a variety of environmental contaminants, and compounds such as PCBs, DDT metabolites and other pesticides, and perfluoralkyl compounds were found at concentrations above threshold levels of concern for health and reproduction in a number of resident dolphins. Background information on the resident dolphins provided an opportunity to investigate relationships between contaminant accumulation and life history, identifying increasing concentrations with age for males, and depuration through lactation for females, correlated with higher than expected mortality of first-born calves. Mercury occurs in high concentrations in resident dolphins, but the potential for adverse impacts may be neutralized by interactions with selenium. Several potential biomarkers of environmental contaminant exposure or effects were investigated, with mixed results. Biotoxins such as brevetoxins from red tide blooms were found to persist in dolphin prey fish and dolphin tissues well beyond the events themselves.

The Project examined dolphin feeding ecology and habitat use from several perspectives. Dolphin diets were examined from stomach contents and stable isotope analyses. Both demonstrated the importance of seagrass habitats to the dolphins because of the role of seagrass meadows in the lives of the dolphins' prey fish. Analyses of stomach contents relative to the availability of prey fish found selection for certain species, especially soniferous (noise-making) fish. Dramatic reduction in prey availability during a severe red tide was correlated with changes in dolphin distribution and group size within Sarasota Bay, presumed emigrations, and declines in body condition. Increased human interactions in Sarasota Bay and nearby waters in the form of depredation of angler bait and catch, along with unprecedented mortality from fishing gear ingestion, occurred following the severe red tide of 2005, before prey fish stocks recovered.

Building on previous studies demonstrating behavioral responses of dolphins to vessels, focal animal behavioral observations with concurrent acoustic recordings found that dolphin whistle patterns changed as boats approached. Unprecedented details on responses of dolphins to boat approaches were obtained through the developmental testing and deployment of digital archival recording tags, showing increased fluke beat rates and depth as correlates of boat approaches.

The Project demonstrated a high level of scientific productivity. The Project resulted in, or contributed to, more than 60 published peer-reviewed scientific journal articles or technical reports, with another 11 currently "in press" and ten more submitted to journals and undergoing peer review. The Project has contributed to graduate student research efforts through field work opportunities, samples, or guidance from program staff, resulting in the completion of eight doctoral dissertations, with four more in progress, and ten Master's theses, with one more in progress. The research team made more than 150 scientific presentations, and more than 60 public and university lectures on topics related to the Project.

The scientific and educational products from the seven years of work performed under the Project demonstrated the value of long-term research on dolphins with long life spans, and specifically the value of the unique natural laboratory of Sarasota Bay, where unparalleled details on the lives of residents have been compiled over the past 38 years. Brief snapshots of dolphin lives provide an incomplete picture of the range of variability exhibited by individuals and populations, and trends are difficult to identify and interpret. Maintaining the continuity and

consistency of the long-term efforts of the Chicago Zoological Society's Sarasota Dolphin Research Program leverages a great deal of information of importance for responsible management and conservation of coastal bottlenose dolphin populations.

### **Purpose**

Bottlenose dolphins (*Tursiops truncatus*) are among the cetacean species most impacted by human activities in the coastal waters of the United States and around the world. They are exposed to a number of activities that have the potential to adversely impact their survival and reproduction. Some of the threats of most concern along the central west coast of Florida are:

1. Pollution from industrial, agricultural, and residential sources;
2. Loss and/or degradation of dolphin habitat;
3. Interactions and competition with commercial fisheries;
4. Injury and mortality from recreational fishing activities;
5. Boat collisions and disturbance from increasing vessel traffic and other sources of noise;
6. Human feeding of wild dolphins.

The National Marine Fisheries Service (NMFS) has been tasked under the Marine Mammal Protection Act with protection of cetaceans in the waters of the United States, including bottlenose dolphins in the Gulf of Mexico. Management of cetacean stocks and the threats they face requires knowledge of the nature and scope of the threats, and cumulative impacts when considered along with natural sources of mortality and serious injury. Evaluation of the nature and scope of the threats to bottlenose dolphins requires a detailed understanding of the species.

The Sarasota Dolphin Research Program (SDRP), operated by the Chicago Zoological Society and based at Mote Marine Laboratory in Sarasota, Florida, is dedicated to the conservation of marine mammals. This is accomplished by conducting scientific research of the highest quality possible, by providing training and educational opportunities, and by disseminating the information collected, through scientific and non-technical articles and reports, and by presentations at professional meetings and public lectures. The SDRP, initiated in 1970, is the world's longest-running study of a wild dolphin population, focusing on the long-term, multi-generational resident bottlenose dolphins along the central west coast of Florida.

An ongoing insufficiency of bottlenose dolphin research funds within the NMFS, in spite of important issues facing these animals, prompted the development of a research initiative in the form of a request for new funds for the NMFS to be able to supplement their existing programs. These funds were applied to a multi-year research partnership involving the NMFS Southeast Regional Office and the SDRP through a collaboration of the Chicago Zoological Society and Mote Marine Laboratory. The partnership, referred to as the "Center for Dolphin Biology, Health, and Conservation Education," conducted research and educational activities during the period 1 July 2001 through 30 June 2008. The partnership took advantage of the SDRP's expertise and unique long-term natural laboratory situation in Sarasota Bay in order to extend the capacity of NMFS to address pressing issues, and to meet the primary program objective of advancing our knowledge of the biology, ecology, behavior, and health of bottlenose dolphins, ultimately leading to better and more appropriate protection for them.

## Approach

The SDRP uses a multi-disciplinary collaborative approach for research and education to address questions and issues of importance to dolphin conservation. The program complements its assets of a highly-experienced staff and a unique long-term natural laboratory situation for bottlenose dolphin research with the involvement of collaborating specialists from around the world. The multi-faceted work for the project was performed by our research team through a set of six “Jobs” (listed below). These Jobs involved the application of a number of established research techniques, especially photographic identification, focal animal behavioral observations, and remote or capture-release sampling of bottlenose dolphins. Field research occurred along the central west coast of Florida from Tampa Bay through Pine Island Sound, with emphasis on the long-term resident dolphins of Sarasota Bay (Figure 1). Photographs, samples and data have undergone analysis, and the resulting information is being disseminated through peer-reviewed scientific journals, technical reports, scientific presentations, public and university lectures, Master’s theses, and doctoral dissertations, as listed at the end of this report.

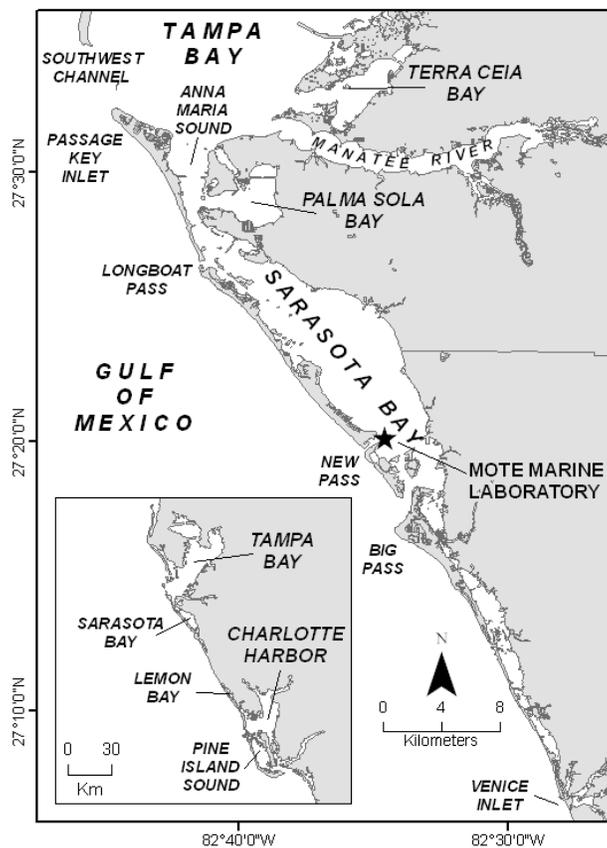


Figure 1. Study area along the central west coast of Florida. The program’s base of operations on Sarasota Bay at Mote Marine Laboratory is indicated by the star.

A principal component of the SDRP research approach is to follow identifiable individual dolphins through time. The compilation of "case histories" for known individuals is a powerful tool for learning about the lives and needs of animals. One of the first and most important contributions of the program following its initiation in 1970 was the determination that coastal bottlenose dolphins in Florida waters inhabit long-term, multi-generation, year-round ranges. The recognition of dolphin residency also set the stage for long-term research into life history and population dynamics, health and effects of environmental contaminants, and social structure. Knowledge of how long dolphins live, when they reach sexual maturity, how often they produce calves, how many calves survive, how frequently dolphins immigrate or emigrate under normal circumstances, and what constitutes "natural" mortality is crucial for understanding how a population might respond to human impacts or to a natural catastrophe. Deviations from normal patterns can be indicative of problems requiring closer scrutiny by government wildlife management agencies, either through research or intervention. Longitudinal studies of the Sarasota dolphin community have provided the first and most complete empirical information on the life history patterns and vital rates of a living population of bottlenose dolphins. These values are used as baselines to evaluate the dynamics of other dolphin populations. With NMFS support for this project, we have been able to expand and extend the baseline and enhance the program's ability to investigate a variety of environmental and other variables that might impact the population.

Currently, the SDRP maintains records of nearly 3,500 individually-identifiable dolphins from the central west coast of Florida. Of these, about 160 individuals spanning five generations regularly inhabit the "natural laboratory" of Sarasota Bay. A quarter of the dolphins first tagged in 1970-1971 are still seen, and some residents have been observed more than 1,250 times over more than three decades. Most of the dolphins frequenting Sarasota Bay are of known sex, age, reproductive and medical histories, ranging patterns, social patterns, and genealogy. As with studies on human health, such background information on the individuals is crucial. Sarasota Bay offers an unparalleled opportunity to evaluate the risks facing dolphins, through research on the threats and their impacts on individuals, and through research on the structure and dynamics of populations that allow more accurate assessment of these impacts at broader levels, as accomplished through the set of Jobs listed below.

Descriptions of the investigative teams and the work performed specifically for each Job are presented under "Findings" below. This work was coordinated by the SDRP, under the direction of Principal Investigator Randall Wells, and administered by the Chicago Zoological Society.

#### Job 1. Population Structure, Dynamics, and Stock Identification

- 1a. Sarasota Bay Dolphin Monitoring
  - 1a.1. Seasonal Synoptic Sarasota Surveys
- 1b. Stock Structure and Vital Rates of Bottlenose Dolphins in Charlotte Harbor
- 1c. Stock Structure of Dolphins in Gulf of Mexico Coastal Waters from Mitochondrial DNA and Microsatellite Markers
  - 1c.1. Stock Structure along the central west coast of Florida
  - 1c.2. Stock Identification and Structure along Florida's northwest coast
- 1d. Modeling for Stock Identification
  - 1d.1. Genetic Analyses of Stock Structure in Tampa Bay
  - 1d.2. Genetic Examination of "New" Dolphins in Sarasota Bay
  - 1d.3. Boundary Rank Program Development and Testing
- 1e. The Role of Social Behavior in Population Structure and Dynamics

- 1e.1. The Reproductive and Ecological Functions of the Pair Bond between Adult Male Bottlenose Dolphins
- 1e.2. Dynamics of Group Fission-Fusion: Social and Ecological Conditions that Influence a Bottlenose Dolphin's Decision to Leave and Join Temporary Groups
- 1e.3. Behavioral and Ecological Influences on Survival Strategies of Juvenile Bottlenose Dolphins in Sarasota Bay, Florida
- 1e.4. Analyses of Genetic Relatedness within a Dolphin Community
- 1f. Population Dynamics Modeling Workshop
- 1g. Vortex Software Enhancement for Population Viability Analyses
- Job 2. Health Assessment and Biomarkers of Environmental Contaminants and Their Effects
  - 2a. Health Assessment and Contaminant Studies
    - 2a.1. Seasonal Sarasota Bay Dolphin Health Assessment and Contaminant Sampling and Analyses
    - 2a.2. Charlotte Harbor Dolphin Health Assessment and Contaminant Sampling
    - 2a.3. Health Assessment Modeling
    - 2a.4. Effects of Biotoxins on Marine Mammals
  - 2b. Biomarker Studies
    - 2b.1. IWC Pollution 2000+ Program
    - 2b.2. Fatty Acids as Biomarkers
    - 2b.3. Mercury and Selenium in Dolphin Tissues
- Job 3. Ecological Relationships (previously, Feeding Ecology)
  - 3a. Using Stomach Content Analyses and Stable Isotopes to Understand Feeding Ecology
  - 3b. Using Fatty Acid Signatures to Identify Feeding Preferences
  - 3c. Relating Dolphin Habitat Use and Population Parameters to Prey Distribution and Abundance
  - 3d. Predation Pressure on Dolphins in Sarasota Bay
- Job 4. Human Interactions
  - 4a. Effects of Watercraft Activity on the Acoustic Behavior of Bottlenose Dolphins
  - 4b. Effects of Vessel Traffic on Dolphin Habitat Use
  - 4c. Tag Development for Studies of Human Impacts on Cetaceans
  - 4d. Effects of Anthropogenic Noise on Habitat Selection and Foraging (subsumed into 4b)
- Job 5. Graduate Student Research
- Job 6. Dissemination of Information
  - 6a. Manuscripts and Reports
  - 6b. Educational Programs
  - 6c. Data Analysis (Statistical Consultations, GIS, Modeling)

## Findings

The Project demonstrated a high level of scientific productivity. The Project resulted in, or contributed to, more than 60 published peer-reviewed scientific journal articles or technical reports, with another 11 currently “in press” and ten more submitted to journals and undergoing review. The program has contributed to graduate student research efforts through field work opportunities, samples, or guidance from program staff, resulting in the completion of eight doctoral dissertations, with four more in progress, and ten Master’s theses, with one more in progress. The research team made more than 150 scientific presentations, and more than 60 public and university lectures on topics related to the Project.

The Project led to the development and/or enhancement of several unique long-term databases used to varying degrees in the performance of different Jobs:

- Bottlenose Dolphin Sighting Database for the Central West Coast of Florida: (1970-present) includes 35,483 dolphin group sightings, 100,730 identifications of distinctive individual dolphins, derived from a photographic identification catalog of 3,453 individually-identifiable dolphins. Some individuals have been re-sighted more than 1,250 times. Data include location, date, time, environmental conditions, activities, numbers of dolphins and calves, individuals present, maintained in Microsoft Access. The dataset from 1993 to the present is the most consistent, with sighting surveys conducted over ten days each month, year-round.
- Sarasota Bay Female Reproductive History Database (1970-present): As a distinct subset of the Sighting Database, detailed records are compiled of the reproductive histories of each of the adult females that use Sarasota Bay on a regular basis. Data include birthdates of calves, calf sex, mother's age at time of birth (including age at first birth in some cases), duration of the mother-calf association, and circumstances leading to separation. The data set currently includes records from 107 resident females and 310 of their calves; some females have been observed with as many as 9 different offspring over the course of their lifetime.
- Bottlenose Dolphin Body Condition and Morphometrics Database: (1984-present) Resident bottlenose dolphins of Sarasota Bay have been captured, measured, and released on-site during health assessments. Data collected include weight, a standard suite of length and girth measures, and ultrasonic measurement of blubber thickness at standard sites. Measurements are available for 225 individuals (some measured up to 14 times), with 684 sets of measurements compiled in an Excel database.
- Bottlenose Dolphin Stranding Database (1985-present): Mote Marine Laboratory's Stranding Investigations Program responds to reports of stranded, sick and injured marine mammals in Sarasota, Manatee, and Charlotte Counties, which includes and extends beyond the Sarasota Bay bottlenose dolphin home range. Carcasses are examined and necropsied for determination of cause of death and for collection of standardized measurements and biological samples, including stomach contents. To date, 427 bottlenose dolphins have been recovered from the central west coast of Florida, including 67 with sighting histories in our database. Stomach contents have been collected from 33 Sarasota Bay residents.
- Bottlenose Dolphin Health Database (1988-present): Resident bottlenose dolphins of Sarasota Bay have been captured, sampled, received full veterinary examinations, and been released on-site, to evaluate health. Blood sample and exam data including 689 sets of measurements from 219 individuals (some sampled up to 15 times) are compiled into an Excel database.
- Sarasota Bay Fish Surveys: (2004-present): Quantitative purse-seine survey operations conducted during winter and summer field seasons have quantified the relative

abundance, distributions, length-frequencies, body conditions, and species assemblages of fish using Sarasota Bay. During 869 sets of the purse seine, 350,215 fish of more than 132 species have been caught, examined, measured, and released. Fish data were collected along with environmental data (habitat type; turbidity; *Karenia brevis* abundance; and vertical profiles of dissolved oxygen concentration, temperature, and salinity) and geographical data on location and habitat type, specifically for GIS analyses.

The application of these and other datasets toward performance of the Project is described for each Job individually below, with summaries of accomplishments, findings, issues that may have impacted performance, and suggestions for future work, as appropriate. For most Jobs, details of methods and findings can be found in published manuscripts or reports. Brief summaries will be provided in this report, along with citations referring the reader to the hard and electronic copies of the published papers (submitted with this report).

### **Job 1. Population Structure, Dynamics, and Stock Identification**

**Project Synopsis:** This project examined the structure and dynamics of bottlenose dolphin population units along the central west coast of Florida. Determining the relationships between community structure and population structure, and how these can be reconciled with the need for practical management units continues to be a major focus of our research program.

#### **1a. Sarasota Bay Dolphin Monitoring**

**Project Synopsis:** Continuation of the long-term dolphin monitoring in Sarasota Bay was central to many other Jobs identified for this work plan, in that it provided the requisite data to define population structure, monitor population vital rates, and it provided the basic background information required for behavioral studies involving specific identifiable individuals. Funds from this initiative, along with continuing funding from Earthwatch Institute, supported ongoing photographic and data analyses.

**Participants:** SDRP staff

**Accomplishments and Findings:** We successfully completed the grant-supported aspects of this ongoing work. Photographic identification surveys were conducted on ten days each month as planned, and were supplemented with periodic synoptic surveys (Job 1a.1), as well as sighting records from boats involved in other aspects of dolphin research in Sarasota Bay and vicinity. Since 1970, we have compiled records of 35,483 dolphin group sightings, with 100,730 identifications of distinctive individual dolphins. These surveys have documented the presence, absence, condition, and reproductive status of the dolphins using Sarasota Bay on a regular basis. They have demonstrated a downward trend in the numbers of dolphins using the bay since 2002, correlated with a decline in immigration (Figure 2) and increased mortality and emigration (Figure 3) as compared to the late 1990s. The period of decline coincided with a series of red tide events including a severe event in 2005 that involved the mortality of most of the normal dolphin prey fish in the bay (D. Gannon et al. in revision, J. Gannon et al. in revision) and an increase in dolphin mortalities from interactions with anglers (Wells et al. in press).

The ongoing photographic identification surveys also provided an opportunity to evaluate the consequences of injuries on survival and reproduction of dolphins under circumstances where the animals could be expected to be re-sighted over time (Wells et al. in press). This information was compiled at the request of NMFS for the NMFS Serious Injury Technical Workshop held in

Seattle in September 2007, and for presentation at the NMFS Joint Scientific Review Group meeting held in Monterey in January 2008. Extrapolations from the bottlenose dolphin situation have been applied to offshore cetacean species that are less conducive to detailed long-term study, in order to assess the seriousness of injuries from fishing gear and vessel strikes.

As Sarasota Bay dolphin abundance data are peer-reviewed for publication, they will be provided to NMFS for incorporation into Marine Mammal Stock Assessment Reports (SARs). The current NMFS estimate for Sarasota Bay in the SAR is out of date and therefore no longer usable.

**Need for Additional Work:** It is vitally important to continue the long-term monitoring of the Sarasota Bay dolphins into the future, maintaining consistency and continuity in data collection. Building on the first 38 years of this unique dataset, this provides the basis for identifying changes and for testing hypotheses about factors that may be influencing the population unit. The apparent correlations between dolphin population increases and presumed increased carrying capacity of the bay following a statewide commercial net fishing ban in 1995, and decreases correlated with a series of red tides should be investigated in greater detail. Data on fish abundance from direct studies in Sarasota Bay or from proxy situations prior to the initiation of Sarasota Bay purse seining operations should be incorporated into analyses of changes in abundance and vital rates, including population growth rates.

#### **1a.1. Seasonal Synoptic Sarasota Surveys**

**Project Synopsis:** Three seasonal synoptic surveys were to be conducted each year through the waters used by the long-term resident Sarasota bottlenose dolphin community in order to better document their presence, status, habitat use, and social patterns. The plan called for three vessels to be operated simultaneously during each survey to standardize and optimize coverage of the dolphins' range.

**Participants:** SDRP staff

**Accomplishments and Findings:** We successfully completed three seasonal synoptic surveys during each year of the project, as planned. Findings have been summarized under "1a. Sarasota Bay Dolphin Monitoring" above.

**Need for Additional Work:** The intensive short-term effort of synoptic surveys provides an important complement to regular monthly surveys in order to provide information on the presence/absence of identifiable dolphins. This component should be continued.

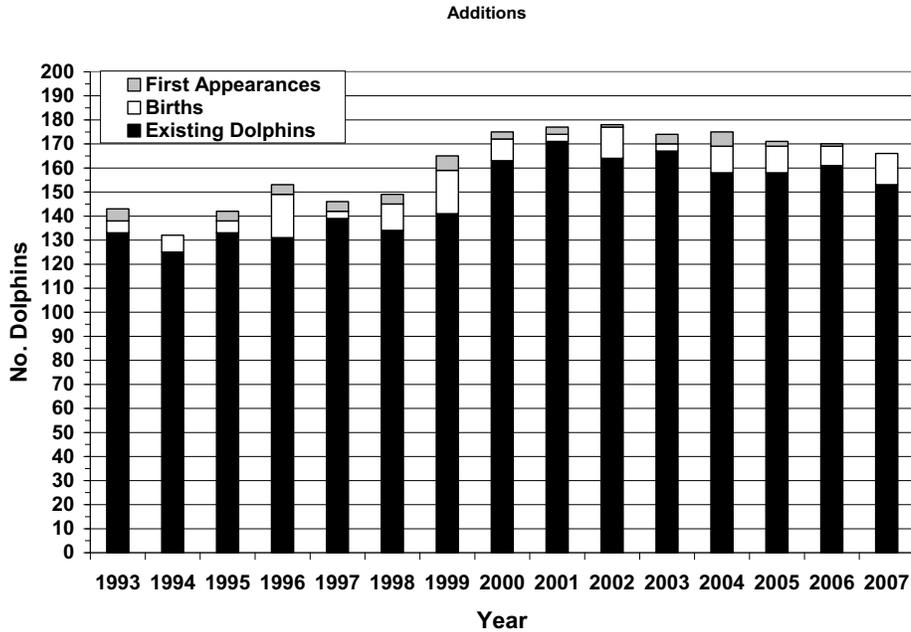


Figure 2. Number of dolphins using Sarasota Bay on a regular basis during years of consistent, year-round photographic identification survey effort, depicting additions to the population unit. Births are scored from records of neonates observed alongside well-known resident females. First appearances include primarily non-calf immigrants, but may also include a few dolphins with un-tracked changed identification features.

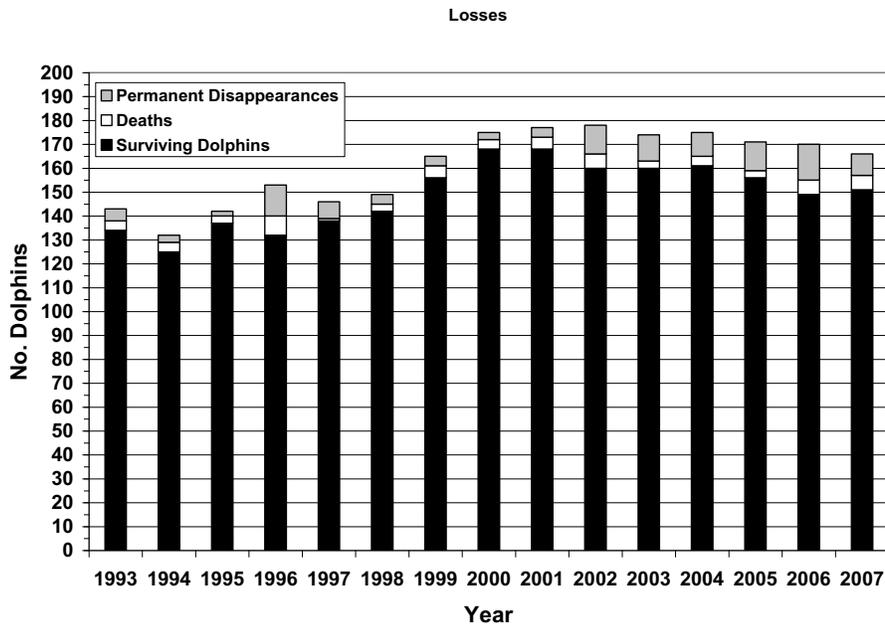


Figure 3. Number of dolphins using Sarasota Bay on a regular basis during years of consistent, year-round photographic identification survey effort, depicting losses from the population unit. Deaths are scored from recovered carcasses and records of disappearances of dependent calves. Disappearances may be emigrants, un-recovered carcasses, or changed identification features.

## **1b. Stock Structure and Vital Rates of Bottlenose Dolphins in Charlotte Harbor**

**Project Synopsis:** We used photographic identification surveys and biopsy dart sampling to investigate population structure and dynamics in Charlotte Harbor and Pine Island Sound. NMFS support funded a winter session of photo-ID surveys and biopsy sampling during the first three years of the program, providing support for staff time, field expenses, and laboratory analyses of genetic samples. This research was conducted to better define bottlenose dolphin stock structure in the Harbor, provide updated estimates of abundance and vital rates allowing for assessment of trends, and to establish a base of knowledge that would facilitate the use of the Harbor dolphins as indicators of ecosystem health, as part of a larger-scale Mote Scientific Foundation (MSF) study of the ecology of the Harbor. The NMFS-sponsored winter field work was matched with summer/fall MSF-sponsored field work to provide comparative seasonal data. In addition, a follow-up fall session was funded by Harbor Branch Oceanographic Institution for September 2006.

**Participants:** Kim Hull and other SDRP staff

**Accomplishments and Findings:** All planned photographic identification surveys and biopsy darting field research was successfully completed. Manuscripts summarizing the results relative to residency patterns, abundance, vital rates, and habitat use are currently being developed for submission to peer-reviewed scientific journals, building on early research in the area by our program. Final peer-reviewed abundance estimates will be provided to the National Marine Fisheries Service for incorporation into their marine mammal Stock Assessment Reports.

During 1970-71, and in 1984 our program tagged 15 dolphins in Charlotte Harbor and Pine Island Sound. There were a few opportunistic surveys in the 1980's that established a small catalog of identifiable individuals. Between 1990-1994 in Charlotte Harbor and in 1996 in Pine Island Sound our program conducted photo identification surveys to establish population estimates and trends for the National Marine Fisheries Service. In addition Dr. Suse Shane provided our program with her catalog of identifiable individuals (276 dolphins) and original data from the Pine Island Sound region from 1985-1996. With the recent photo-ID data from 2001 to 2007 this established a 37 year dataset from this region. Preliminary findings indicate that none of dolphins tagged in 1970-71 have been identified in recent years, but all six dolphins tagged in 1984 have been resighted since 1990. During 65 boat-days in 1982-2007, 1157 distinctive dolphins have been identified in the Charlotte Harbor and Pine Island Sound study area. Of these, 141 were seen once, 797 were seen 2-9 times, and 249 were seen on 10 or more days. Two hundred and eighteen individuals (18.8%) were observed only within a single year and are considered transients. The remaining 939 individuals (81.2%) were sighted over two or more years and are considered residents. Overall, 29.5% of dolphins identified in the study area were observed over a ten year period or more and are considered long-term residents. Of the 249 dolphins observed on ten or more days, 205 dolphins were never observed outside the study area. In addition, of 192 dolphins that were sighted on ten or more days both before and after Hurricane Charley, 181 individuals (94.3%) were resighted within the same region of the study area.

In summary, from the longitudinal data we have documented that many individuals are resident to Charlotte Harbor and Pine Island Sound, some for over ten years indicating strong site fidelity to this area. Many individuals were never observed outside of the study area even with considerable effort to the north, although some individuals were observed in Gulf coastal waters and in Sarasota and Tampa Bays. Even after a major Category 4 hurricane in which several

regions in the study area sustained habitat damage, most dolphins were resighted in the same region of the study area after the hurricane. Mark/Proportion and Mark/Recapture analyses of our photo-ID data from 2001-2006 indicated a fairly stable population size, even after the major hurricane.

We also observed and received reports of apparent increases in dolphins entangled in fishing line and stalking and depredating from fishing boats. We have addressed this issue by increasing educational outreach in the area.

Since 2001 we have collected 93 biopsy samples from 88 different dolphins from within Charlotte Harbor and near-shore Gulf waters. Genetic analysis shows that of these 88 dolphins, 65 were male and 23 were female. Genetic analyses were completed during 2006. A small subset of samples ( $n = 11$ ) have been analyzed for environmental contaminants. The remaining samples for contaminant analyses have been archived by NIST for analysis when funds become available for these analyses.

**Need for Additional Work:** In support of congressionally-mandated NMFS Stock Assessment Reports and trend analyses, periodic photographic identification surveys, using methodology consistent with that used for this project, will be required to provide updated abundance estimates. In addition, analyses of archived blubber samples would provide important information on geographical variation in environmental contaminant concentrations and risks to coastal bottlenose dolphins (Schwacke et al. 2002, Hansen et al. 2004).

### **1c. Stock Structure of Dolphins in Gulf Of Mexico Coastal Waters from Mitochondrial DNA and Microsatellite Markers**

**Project Synopsis:** Little is known of the structure of bottlenose dolphin stocks in the Gulf of Mexico coastal waters immediately offshore of, or between, the bay, sound, and estuary stocks in Florida waters. We undertook two studies to examine this issue. The first involved genetic sampling of Gulf dolphins immediately offshore of Sarasota Bay and adjacent waters, as part of Anna Sellas' Masters thesis. The second was a project initiated in Spring 2004 in response to an unusual mortality event in the vicinity of the St. Joseph Bay in the Florida Panhandle. Samples were collected to primarily compare to carcass samples in order to help NMFS to evaluate the stock of origin of the dead animals, and secondarily to begin to develop an understanding of the genetic stock structure of dolphins in the western panhandle. Preliminary analysis of the biopsy samples and samples from both unusual mortality events (1999 and 2004) have shown that all three sampling periods are composed of different stocks.

#### **1c.1. Stock Structure along the central west coast of Florida**

**Project Synopsis:** The objective of this project was to determine the amount of genetic exchange between the resident Sarasota Bay bottlenose dolphins and those of the adjacent coastal Gulf of Mexico waters. In addition, this project aims to investigate social unit structure of coastal Gulf dolphins by estimating relatedness of individuals using genetic techniques. This project involved the analysis of skin samples collected from 54 resident bottlenose dolphins in Sarasota Bay during live capture projects, and 70 biopsy samples from dolphins in adjacent Gulf of Mexico waters, collected using a biopsy dart method.

**Participants:** Anna Sellas and other SDRP staff

**Accomplishments and Findings:** This project was officially and successfully completed when Anna Sellas graduated in June of 2002. Results of this research were presented at her thesis defense at the University of California, Santa Cruz, and were submitted in written format as a Master of Science thesis, and they were published in 2005 in *Conservation Genetics* (Sellas et al. 2005). With respect to genetic structure, three main conclusions were drawn from this research: (1) Comparisons of nucleotide diversity estimates and haplotype frequency estimates showed coastal Gulf dolphins are genetically more diverse than resident dolphins of Sarasota Bay, FL. (2) From estimates of population subdivision based on mitochondrial and microsatellite DNA data, significant differentiation was detected between the coastal Gulf dolphins and resident dolphins of Sarasota Bay, FL. (3) When substructure was examined for each sex independently, higher differentiation was detected between females than males, supporting previous findings based on photo-identification that males are moving between these populations more often than females (Duffield and Wells 2002, Wells 2003, Fazioli et al. 2006). The genetic differences found between Sarasota Bay and the coastal Gulf of Mexico support the current, separate identification of stocks for these areas, as presented in NMFS Marine Mammal Stock Assessment Reports.

**Need for Additional Work:** Results from this project underscore the importance of examining genetic data when defining stocks or units for management. Since this study examined only two relatively small locations, further studies are needed to more accurately identify the population structure of bottlenose dolphins throughout the Gulf of Mexico.

### **1c.2 Stock Identification and Structure along Florida's northwest coast**

**Project Synopsis:** Little is known about stock identification and structure along the Gulf of Mexico coast north of Tampa Bay, Florida, through the Florida panhandle. Appropriate management requires a capacity to identify and distinguish between stocks of bottlenose dolphins. We used biopsy darting for genetic sampling in conjunction with photographic identification to expand our stock ID and stock structure research into this open coastal habitat, as well as into the associated bays, rivers and marshes. The first phase of this project was implemented near St. Joseph Bay in the panhandle in response to the Unusual Mortality Event (UME) that occurred in March-April 2004 in this area. As a result of the deaths of more than 100 dolphins in this region, it became increasingly important to identify and evaluate the stock structure and status of bottlenose dolphins in the region. Radio-tracking data obtained in association with NOAA dolphin health assessment efforts in this area during 2005 and 2006 supplemented the photo-ID and genetic data for describing stock structure and obtaining abundance estimates for this region. This project formed the basis for Master's degree research by Brian Balmer, through the University of North Carolina, Wilmington.

**Participants:** Brian Balmer and other SDRP staff, Dr. Patty Rosel, NMFS, Dr. Sue Carney, Mote Marine Laboratory

**Accomplishments and Findings:** This project was completed successfully with the defense of Brian Balmer's Master's thesis in April 2007, and genetic analyses by Dr. Patty Rosel comparing the genetic composition of the UME dolphins to dolphins in the area post-UME. A manuscript generated from Balmer's thesis has been accepted by the *Journal of Cetacean Research and Management* (Balmer et al. in press). The peer-reviewed abundance estimates from the St.

Joseph Bay area have been provided to NMFS for their marine mammal Stock Assessment Reports; previous NMFS abundance estimates for this stock were out of date and therefore no longer valid.

Photo-identification of bottlenose dolphins in the St. Joseph Bay region was conducted during 145 boat-days from April 2004 through June 2007. Photo-identification effort included mark-recapture surveys, biopsy dart sampling, and radio tracking of individuals that were investigated during capture-release health assessment studies carried out by NOAA in April 2005 and July 2006. In total, 305 individual bottlenose dolphins were identified and 68 biopsy dart samples were obtained in the St. Joseph Bay region. Mark-recapture surveys to estimate seasonal abundance were conducted during February/March, April, May, and July 2005, February and September/October 2006, and June/July 2007. Mark-recapture models estimated the highest abundances in May 2005 followed by September/October 2006, and the lowest in July 2005, February 2006, and June/July 2007. Mark-recapture techniques as well as direct counts from photo-identification have provided data that suggest spring and fall fluctuations of animals in the St. Joseph Bay region, which may be similar to those seen in other parts of the Gulf of Mexico. These data also provide evidence that animals sighted in the winter and summer months are those that are more likely to be sighted year-round in the St. Joseph Bay region suggesting some degree of residency by certain individuals.

In April 2005 and July 2006, researchers from NOAA Fisheries, Mote Marine Laboratory, Chicago Zoological Society, University of North Carolina Wilmington, Florida State University and several other organizations participated in bottlenose dolphin health assessments in St. Joseph Bay, Florida. The two major goals of this study were to carry out a detailed health assessment of the bottlenose dolphins in St. Joseph Bay and to deploy radio transmitters on a subset of individuals. Twenty-four individual dolphins, twelve females and twelve males, were radio tagged during April 18-28, 2005 and July 17-28, 2006. Radio tracking surveys by vessel were conducted daily with the goal of locating each tagged animal every day for the life of the radio tag. The primary tracking platform was a 7 m long center-console vessel. However, when weather conditions were too poor to track by vessel (Beaufort Sea State > 3), animal locations were triangulated from a land-based vehicle. Since there had been no prior data on movement patterns of animals in this region, it was important to ascertain if individual animals were leaving the area covered by boat or vehicle. Six aerial surveys were flown during the 2005 tracking period in a Cessna O-2A "Skymaster" fixed with two, strut mounted 'H' antennas (Telonics, Mesa, AZ). Radio tagged dolphin utilization areas were estimated by calculating the distance of shoreline between the farthest northwest and southeast location, and multiplying that distance by the maximum distance the dolphin was located offshore.

The April 2005 and July 2006 data indicated the presence of animals with differing utilization area patterns within the defined geographic region of study. Photo-identification data in conjunction with the radio tracking analyses supported the idea of different groups of animals in the St. Joseph Bay region. The first group appeared to be animals with large utilization areas, greater than 200 km<sup>2</sup>, that spend only several months during the year in the St. Joseph Bay region. The second group includes those with utilization areas between 100 and 200 km<sup>2</sup>, which spend a larger portion of the year in the St. Joseph Bay region, but utilization areas may extend outside the photo-identification boundaries. Individuals with UAs less than 100 km<sup>2</sup> appeared to comprise the last group. These animals have utilization areas that only encompass a select area inside the St. Joseph Bay region and remain in that region year round.

Genetic samples collected from a number of sites on the west coast of Florida were analyzed by Dr. Sue Carney (Mote Marine Laboratory) and Dr. Patty Rosel (NMFS) during 2006. This work was motivated in part by 1999 and 2004 UMEs in the Florida panhandle. Samples collected by biopsy darting were processed from 105 animals from five regions – Sarasota Bay (n = 22), Tampa Bay (n = 22), Charlotte Harbor (n = 13), Tallahassee (n = 32), St. Joseph Bay (n = 16). DNA was extracted at Mote Marine Laboratory in Sarasota, Florida. Gender determination of all samples was made by a polymerase chain reaction (PCR) assay (Rosel, 2003), and a 450-base pair portion of the mitochondrial control region was sequenced for each individual using the primers H16265 and L15824 (Rosel, 1999). Forward and reverse strands were individually edited by eye and then assembled in Sequencher v.4.7 (Gene Codes Corporation) to confirm the identity of each nucleotide. Using facilities at the National Marine Fisheries Service Laboratory in Lafayette, Louisiana, each of the 105 samples was then genotyped at 19 different microsatellite DNA loci on an ABI 310 Genetic Analyzer (Applied Biosystems, Foster City, CA). Confirmation of each scored allele was made using Genescan Analysis 3.1 and Genotyper 2.1 software (Applied Biosystems).

Significant genetic differentiation was found between the biopsy samples collected in the St. Joseph Bay area and samples collected from the 2004 UME in St. Joseph Bay suggesting those animals that were biopsied in 2004 and 2005 did not come from the same population as those that died during the 2004 UME. Several possibilities exist to explain this result. If the animals that stranded dead during the 2004 UME floated from some distance before landing on the beaches around and in St. Joseph Bay, they would not be representative of the local population of that area.

Alternatively, many of the biopsy samples were collected outside St. Joseph Bay, near Mexico Beach, FL and further west. If population subdivision in bottlenose dolphins along this coast is of a very fine scale, then the biopsies, while they include some animals that spend a majority of their time in St. Joseph Bay, may also include members of other populations, thereby inflating the difference between the two sample sets. Similar to this, it has been found that St. Joseph Bay sees an influx of animals in April and May (Balmer et al. in press). Since the UME samples were collected in March and the biopsies in late April and May, it is possible that those animals biopsied in St. Joseph Bay, again, do not represent the animals present there earlier in the spring and winter.

As a variant to the alternative hypothesis above, the genetic differentiation between the UME dolphins in St. Joseph Bay and the biopsied live dolphins in the area might also have resulted from elimination of the resident dolphins of St. Joseph Bay by the UME, with re-population now occurring from sources from outside the bay. Further genetic analyses using additional samples collected on a much finer scale and across a broader area, including farther offshore, will be necessary to tease apart these alternatives.

**Need for Additional Work:** Further genetic analyses using additional samples collected on a much finer scale and across a broader area, including farther offshore, are necessary to tease apart the alternative hypotheses surrounding the genetic differences between the biopsied dolphins and the UME carcasses to determine what stock(s) of dolphins were impacted by the UMEs and to further differentiate stocks in the region. Also, additional photo-ID and/or tracking efforts are necessary to determine the movement patterns of individuals sighted only during spring and fall in St. Joseph Bay, during the periods of time when they are not within this region.

## Literature Cited

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### **1d. Modeling for Stock Identification**

**Project Synopsis:** We employed a multi-method approach incorporating a variety of data into identification of stock structure along the central west coast of Florida (Sarasota Bay, Charlotte Harbor, Tampa Bay, adjacent Gulf of Mexico waters), working with NMFS colleagues to investigate the use of a geographically-constrained hierarchical clustering model using genetic data from dolphins. In addition to genetic data, ranging, and social association data, we examined the utility of using contaminants and isotopic ratios to discriminate stocks. Concurrent photo-ID and biopsy darting or health assessments of dolphins recorded during earlier surveys provided data on genetics, ranging patterns, social associations, and environmental contaminants.

#### **1d.1. Genetic Analyses of Stock Structure in Tampa Bay**

**Project Synopsis:** We conducted photographic identification surveys and biopsy darting for genetic sampling in order to test hypotheses about fine-scale dolphin population structure in Tampa Bay. Results of analyses of data from long-term photographic identification studies suggested the existence of dolphin communities in Tampa Bay, based on ranging and social association data. We obtained genetic samples from identifiable members of putative dolphin communities in Tampa Bay to see if there is a genetic correlation with the behavioral data, and thus a stronger biological basis to this level of population structure. As part of this project, photographic identification databases in Tampa Bay was also continued.

**Participants:** Kim Urian, Brian Balmer and other SDRP staff

**Accomplishments and Findings:** This project proceeded as planned through the phases of collecting most of the desired genetic samples and identification photos, but our initial plan for data analysis using Boundary Rank (see 1d.3, below) was not possible due to the fact that the basic manuscript on the technique was not accepted for publication. During 2000, 2002, 2003 and 2004 we conducted photographic identification surveys and biopsy darting for genetic sampling in Tampa Bay to collect sufficient samples to ensure representative coverage from all communities in Tampa Bay. We approached our goal of 30 samples from each community. We also conducted photo-identification sampling during these biopsy efforts. From photo-identification images taken during 2003 and 2004, we have identified 227 individual dolphins. Of these, we matched 82 dolphins to our Tampa Bay Photo-identification Catalog; 26 dolphins were photographed in both years. Nearly all the dolphins that we matched to the Tampa Bay Catalog were first identified during surveys we conducted between 1988-1993, indicating that a large proportion of these dolphins were long-term residents of these waters. Approximately half of the 99 dolphins we sampled were matched to the Tampa Bay Catalog.

Because the Boundary Rank manuscript was not accepted for publication (see 1d.3, below), our original plan to evaluate community (or stock) structure in Tampa Bay with this novel genetic approach was not possible. However, we developed a new, quantitative approach to apply data on ranging patterns and social associations to evaluation of stock structure. We applied hierarchical cluster analysis to locations and association indices (CoA) for 102 dolphins

with 10 or more sightings collected during photo-identification surveys in Tampa Bay during 1988-1993 (Urian et al. in review). We used ANOVA to test for differences in mean locations and determine whether mean CoA values within a community were higher than among communities. Dolphins in Tampa Bay clustered into five putative communities differing significantly in location and CoA values. Kernel estimates of the ranges of these five communities exhibited little overlap; some communities had no overlap at all. We concluded that five discrete communities or stocks of bottlenose dolphins exist in Tampa Bay and that such fine-scale structure may be a common feature of bottlenose dolphin populations throughout the southeastern United States.

**Need for Additional Work:** Consideration of other variables, such as a measure of genetic structure or contaminant profiles, might help to refine the determination of stock structure, but an acceptable genetic test remains to be developed.

### **1d.2. Genetic Examination of “New” Dolphins in Sarasota Bay**

**Project Synopsis:** Since the mid-1990s there has been an unprecedented increase in the numbers of dolphins using Sarasota Bay, from a 20-year average of about 100 dolphins to more than 150 dolphins in the 2000’s. Some of this increase is a result of recruitment through successful reproduction of long-term residents, but many of the animals appeared in the Bay as juveniles or adults, originating elsewhere. Because these “newcomers” rarely enter waters shallow enough to support our standard capture-release techniques, we used biopsy darting to obtain genetic samples for examination of mitochondrial DNA haplotypes and microsatellites, and to determine sexes as part of our long-term program of monitoring population structure. Blubber obtained from the biopsy darting was archived for organochlorine concentrations. In combination, genetic and contaminant profiles can provide indications of the origins of the animals, allowing evaluation of a previously-undocumented mechanisms for variation in dolphin population structure.

**Participants:** Brian Balmer and other SDRP staff, Dr. Debbie Duffield, Portland State University

**Accomplishments and Findings:** During the course of this project, genetic samples were obtained from 88 dolphins frequenting Sarasota Bay, bringing the total genetic database for Sarasota Bay resident dolphins to 216 individuals, with data still being added from samples collected from carcasses. A total of 8 microsatellite loci have been run for these animals, and mtDNA profiles are being completed.

**Need for Additional Work:** Upon completion of the genetic analyses, data analysis will be performed to examine the original questions regarding the possible source of new animals to Sarasota Bay, and to expand upon previous descriptions of the genetic and social structure of the Sarasota Bay dolphin community (Duffield and Wells 2002).

### **1d.3. Boundary Rank Program Development and Testing**

**Project Synopsis:** There is a strong need for developing objective, quantitative criteria for defining population units of cetaceans. The Sarasota Dolphin Research Program worked with

Drs. Karen Martien and Barb Taylor of NMFS Southwest Fisheries Science Center to develop and test their geographically-constrained hierarchical clustering algorithm with genetic and behavioral data from the well-known dolphins of the central west coast of Florida. The first phase of this project was to test the performance of Boundary Rank, a new hierarchical clustering method, and compare its performance to similar methods. The second phase was to repeat the analyses on an expanded dataset. In addition, we used the extensive sighting histories available for many of the animals included in the dataset to examine the sensitivity of the genetic analytical techniques to sampling location. To do this, we conducted analyses using both the average sighting location of individuals and randomly selected sighting locations as the sample location.

**Participants:** Anna Sellas and other SDRP staff, Dr. Patty Rosel, NMFS, Dr. Karen Martien, NMFS, Dr. Barb Taylor, NMFS, Dr. Debbie Duffield, Portland State University

**Accomplishments and Findings:** This project proceeded as planned, up to the point when the resulting manuscript was not accepted for publication. All of the necessary genetic samples ( $n \geq 50$  from each site) were collected from all four sampling sites: Sarasota Bay, the Gulf of Mexico, Charlotte Harbor, and Tampa Bay, and the genetic analyses of these samples were completed by Anna Sellas through the NMFS lab operated by Dr. Patty Rosel. Findings using the Boundary Rank program indicated that there appears to be a genetic basis to the community structure of coastal bottlenose dolphins, as indicated previously from analysis of ranging and social association patterns (Duffield and Wells 2002, Wells 2003, Sellas et al. 2005, Fazioli et al. 2006, Urian et al. in review). Thus, fine-scale population structuring may be important for identifying the appropriate scope of management. Modeling efforts and investigation of other parameters as stock indicators resulted in a manuscript submitted to *Marine Mammal Science*, but this manuscript was not accepted for publication.

We also participated in several other projects investigating approaches to defining population structure based on different variables. Coastal bottlenose dolphins were previously considered to have a single form of hemoglobin, used to differentiate them from the offshore form. However, a study including samples from Sarasota Bay demonstrated the occurrence of several forms and significant genetic diversity within communities of coastal dolphins (Remington et al. 2007). Mancina et al. (in review) determined that transcriptome can be used to differentiate between dolphin populations, based in part on samples from Sarasota Bay.

**Need for Additional Work:** There remains a strong need for developing objective, quantitative criteria for defining population units of cetaceans through genetic analyses. The work of Urian et al. (in review) provides a quantitative basis for analyzing fine scale stock structure based on behavior, but incorporation of genetic data would increase the power of the approach.

### **1e. The Role of Social Behavior in Population Structure and Dynamics**

We are conducting several studies that will provide a more in-depth understanding of social processes, as they impact population structure and dynamics. These projects will form the basis of graduate theses.

### **1e.1. The Reproductive and Ecological Functions of the Pair Bond between Adult Male Bottlenose Dolphins**

**Project Synopsis:** The main objective of this study was to determine the function of the pair bond which forms between adult male bottlenose dolphins in a free-ranging community in Sarasota Bay, Florida. It had been hypothesized that adult males form these bonds to increase mating opportunities but they may also enhance foraging efficiency and provide increased vigilance and protection against both predators and threatening conspecifics. To distinguish between these reproductive and ecological functions, which are not mutually exclusive, behavioral observations were conducted in both the breeding and non-breeding seasons over two consecutive years on both paired and unpaired adult males.

**Participants:** Edward Owen and other SDRP staff, Stephanie Watwood, Woods Hole Oceanographic Institution/MIT.

**Accomplishments and Findings:** This project was completed successfully, resulting in the completion and successful defense of a doctoral dissertation by Edward Owen through the University of California, Santa Cruz, in July 2003 (Owen 2003) and publication of a manuscript in a peer-reviewed journal (Owen et al. 2002).

Male-male mammalian alliance formation, especially between non-relatives, presents a challenge to evolutionary theory. These alliances are of particular interest because of the opportunity they present to further understand selection mechanisms of cooperation between non-kin. Mammalian males have been documented to cooperate primarily to gain access to females and in agonistic interactions with rival males. Animals may also cooperate in a variety of non-reproductive contexts, although, among cooperating mammalian males, observations of such behaviors have generally been less common than those which occur in a reproductive context.

Owen's dissertation focused on alliances which form between pairs of adult male bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida (Owen 2003). These long-term, stable alliances have previously been hypothesized to serve reproductive and/or ecological functions. The focus of this study was to use behavioral, health, ecological, genetic, and life history data to determine the functions of this pair-bond, and to further our understanding of the evolutionary mechanisms of alliance formation.

In any given year, about 40% of adult males are not members of an alliance (non-alliance males, NAMs). The majority of NAMs are either too young to have formed an alliance, or their alliance partner has died or disappeared and they have not formed a new alliance. Data suggest that alliance formation is the norm among adult males and that unpaired males are a transitional stage rather than an alternative strategy.

Genetic analyses conducted with microsatellite markers and mitochondrial DNA found that on average, alliance males (AMs) are no more related to their partner than to a non-partner male. Therefore, kin selection is not driving alliance formation, and by-product mutualism is presented as a model for alliance formation and maintenance. Prior association and similar age seem to be more important parameters in partner selection for alliance formation than relatedness in the Sarasota Bay bottlenose dolphin community.

Comparisons between AMs and NAMs indicate that alliances function in these bottlenose dolphins in both reproductive and ecological contexts. AMs have greater access than NAMs to females of the greatest reproductive potential, while evidence suggests that AMs also receive

significant ecological benefits. AMs spend more time than NAMs in habitats which may be more predator- and prey-rich. Enhanced vigilance and/or predator protection may provide AMs access to habitats where prey are more abundant, leading to a reduction in time searching for prey. AMs may also be more efficient foragers overall.

Although not supported directly from funds from this project, WHOI/MIT PhD student Stephanie Watwood conducted her dissertation research on whistle use and whistle sharing by allied male bottlenose dolphins in tandem with Owen because they were studying complementary aspects of the lives of the same dolphins. In this way, the project leveraged additional relevant research at no additional cost.

Watwood successfully defended her dissertation (Watwood 2003) and published two peer-reviewed papers as a result of these collaborative efforts (Watwood et al. 2004, 2005). The goal of Watwood's dissertation was to determine the effect of the formation of male alliances on vocal development. Comparing whistles produced in isolation revealed that alliance partners have similar whistles, while non-partners do not. Whistle similarity seen in alliance partners mirrors group-specific vocal convergence in stable groups of birds and bats. Males produce more variable whistles than females, and females have more stable whistle repertoires. Unlike males, females do not maintain the strong, stable relationships seen in male alliances. Increased vocal plasticity in males may be related to modifying whistle production while forming alliances. Females produced whistles that were less similar to other females than to males. Females may rely on whistle distinctiveness for mother-offspring recognition, while males may rely on whistle convergence to maintain specific social bonds. The whistles produced by an isolated individual may not represent its complete repertoire.

A hydrophone array was used to record whistles of free-swimming, socializing individuals to compare to the whistles produced by those animals in isolation. There was no significant difference in the whistle repertoires of restrained vs. free-swimming dolphins for over 60% of the animals, and most produced at least one whistle type in both contexts. Therefore, dolphins use similar whistles in isolated and free-swimming conditions. Recordings of different social groups were examined to test if signature whistles function as contact calls. An allied male produced signature whistles most often when separated from his partner and least often when with his partner. Signature whistles were also highly individually distinctive, and therefore well suited as contact calls, while variant whistles were not. Separations and reunions between alliance partners were examined to determine if whistles are used to maintain contact between preferred associates. Most whistles recorded from separated males were signature whistles. The timing of whistle production was correlated with the timing of the maximum partner separation and the initiation of a reunion. Few whistles were produced as the partners separated. Therefore, whistles may initiate reunions between partners. Watwood's dissertation demonstrated that free-ranging male dolphins use signature whistles in the same way as females and captive dolphins.

**Need for Additional Work:** Several chapters of Owen's dissertation (Owen 2003) remain unpublished due to his transition to the biomedical field soon after graduation. Revision and submission of these papers would provide a useful contribution to the literature on bottlenose dolphin social structure.

## **1e.2. Dynamics of Group Fission-Fusion: Acoustic Mechanisms Used by Bottlenose Dolphins when Leaving and Joining Temporary Groups**

**Project Synopsis:** University of South Florida PhD student Ester Quintana-Rizzo was originally attempting to identify the conditions that influence an individual dolphin's decision to leave and join a group, and to use this information to extrapolate the costs and benefits of being a member of groups of different size and composition. Through the process of graduate committee review of her plans, the project was modified somewhat to emphasize the importance of acoustic mechanisms to initiating group formation and maintaining contact within dolphin groups. The project explored acoustic contact range as a means of defining dolphin groups, and examined the influence of environmental features on transmission of the sounds that might be used for communication by dolphins within groups.

**Accomplishments and Findings:** This project was successfully completed with Quintana-Rizzo's successful defense of her dissertation in December 2006 (Quintana-Rizzo 2006) and the publication of a peer-reviewed manuscript on estimated communication ranges of dolphin groups (Quintana-Rizzo et al. 2006). One more manuscript is in press (Quintana-Rizzo and Wells in press), and three more have been submitted to journals and are in revision (Quintana-Rizzo and Wells in revision, Quintana-Rizzo et al. in revision a,b). The general goals of the project were to: 1) examine the dynamics of fission-fusion of resident bottlenose dolphins in Sarasota Bay, 2) examine the communication signals produced during temporary separations of dolphins, and 3) estimate the distances over which dolphins could remain in acoustic contact while separated. Field work included focal animal behavioral follows and sound transmission experiments. Field work ended in October 2003 with a total of 107 focal follows conducted in 218 hrs and a total of 10 sound transmission experiments.

It was found that a dolphin's decision to join or leave a group was related to social considerations such as the class of individual encountered (e.g., mothers with calves, adult single females, adult males, and juveniles) as dolphins move in different environments. The decision was also influenced by ecological characteristics such as the habitat where a dolphin was found. These two aspects in turn determined the rate of group changes. Mothers with calves regularly using deep waters had high rates of fission-fusion. Those females encountered other females in the same reproductive condition frequently and associated with them. In contrast, mothers with calves using shallow waters had lower fission-fusion rates. Those females encountered juvenile dolphins often but they did not associate with them frequently.

Temporarily-separated dolphins did not always produce the sounds typically used for long-distance communication, and sometimes they did not use any detectable acoustic signal to find each other. On average, this absence of communication occurred at distances less than 50 m. When both whistles and echolocation were produced, they were apparently involved in maintaining contact between mothers and their calves and other associates. Estimates of active spaces defined by whistle transmission indicated that communication range varied between habitats. Shallow seagrass areas had the smallest active space while channels had the greatest active space. Findings indicated that the distances over which dolphins remain in acoustic contact and can be considered members of groups are much greater than has been described from observations of dolphin spacing and activity alone. This has important implications relative to the introduction of anthropogenic sounds into the water that might mask or otherwise interfere with dolphin communications.

**Need for Additional Work:** Efforts are moving forward to revise several submitted manuscripts in response to reviewers' comments.

### **1e.3. Behavioral and Ecological Influences on Survival Strategies of Juvenile Bottlenose Dolphins in Sarasota Bay, Florida**

**Project Synopsis:** The focus of this project was to better understand strategies for survival by juvenile dolphins. By comparing and contrasting different behavioral, social, and ecological elements of the lives of juvenile dolphins, the project would be able to determine crucial ages of independence, better define social and behavioral maturity, and better understand patterns of mortality and survivorship of free-ranging juvenile dolphins. A version of this project was initially intended to form the basis of a Master's thesis for Todd Speakman through the University of California, Santa Cruz, but he withdrew from the program prior to initiation of the project. Beginning in Fall 2004, Katherine McHugh initiated a PhD program through University of California, Davis, in which she is pursuing this topic (Wells serves as co-chair of her graduate committee).

**Participants:** Katherine McHugh, University of California, Davis

**Accomplishments and Findings:** This project has been highly successful in spite of the fact that it was initially placed on hold due to Speakman's withdrawal from the graduate program. McHugh completed her academic requirements, including qualifying examination, in 2006, completed her data collection in summer 2008, and is now focusing on completing data entry and analysis and dissertation and manuscript writing. The main objective of her dissertation project is to better understand behavioral development, sex and seasonal differences in behavior, and factors influencing survivorship of juvenile dolphins after they become independent of their mothers. This research should reveal the range of variability in developmental trajectories of bottlenose dolphins and provide missing data on how juvenile dolphin behavior patterns vary by sex, age, season, and time since weaning. Such information will provide a more comprehensive understanding of dolphin life history and survival strategies, which may have implications for conservation and management of long-lived coastal cetaceans.

McHugh is investigating these questions by combining long-term sighting and mortality data from the resident dolphin community in Sarasota Bay with new information collected via boat-based surveys and focal animal behavioral observations on individually-identifiable juveniles, which will allow for both a longitudinal and cross-sectional perspective on juvenile behavior. Since this project began in 2005, McHugh has conducted over 500 hours of behavioral observations on juvenile dolphins in Sarasota Bay. As fieldwork winds down, McHugh will move fully into data analysis and writing of dissertation chapters for publication. However, there are a few areas in which she has made progress already.

One of the main areas she has explored so far has been the effects of red tide on juvenile dolphin behavior. While not originally intended to be a focus of this study, the first two field seasons coincidentally took place during periods when red tide was a factor. Preliminary analysis has shown that both social behavior and activity budgets differ substantially during red tide. Juveniles associated in larger groups and with significantly more community members, and spent less time foraging and more time socializing during red tide events, potentially as a consequence of underlying changes in relative prey availability and distribution. Preparation of a publication on these findings will begin in the fall, as it has been on hold until fieldwork was

completed in the event that Sarasota Bay experienced another red tide event. Another event might provide a test of hypotheses from the behavioral changes seen in previous years.

In addition to the red tide analysis, McHugh has also worked with long-term SDRP data to examine the transition to independence for dolphin calves, calculating ages of separation and exploring life history, body condition, and social factors influencing the timing of independence for calves born into the Sarasota community since 1980. A paper on this analysis is currently in preparation and will be submitted for publication in the fall 2008. McHugh has presented her preliminary findings at a number of conferences.

**Need for Additional Work:** Having now completed her fieldwork, McHugh is continuing data analysis and writing, with the expectation of completion of her dissertation in summer 2009 along with publications in peer-reviewed scientific journals.

#### **1e.4. Analyses of Genetic Relatedness within a Dolphin Community**

**Project Synopsis:** Dr. Debbie Duffield of Portland State University, has been conducting analyses of new and archived genetic samples along with existing data to develop a more complete understanding of the genetic structure of the Sarasota dolphin community. Of particular interest in this regard was the definition of the role of relatedness in observed social patterns. Building on previous genetic analyses confirming mother-calf pairings, identifying tentative sires, and distinguishing between adjacent population units, Duffield has been examining the degree of relatedness of social associates as one factor that may define group structure.

**Participants:** Randall Wells, SDRP and Debbie Duffield, Portland State University

**Accomplishments and Findings:** The first phase of this project was to generate a summary of our knowledge of the genetic structure of the community based on data available at the initiation of the project, successfully completed in the form of a published manuscript by Duffield and Wells (2002). With this as a starting point, the primary phase supported by this project was the collection and analyses of genetic samples from as many members of the Sarasota Bay dolphin community as possible. This project represents the culmination of 24 years of genetic work on the Sarasota Bay bottlenose dolphin community. Over this time, we have brought a diverse array of genetic tools to the investigation of social structure in a well-known core population of dolphins. We have developed various parts of this picture in previous studies and have now added a complete array of microsatellite DNA data for the Sarasota dolphin community. During this grant period, a post-doc was engaged to complete these analyses and to create a database from which to assess relatedness and paternity. We now have an estimated 1750 microsatellite panels run for this population (8 loci for 216 animals). We are currently in the process of confirming all the mother-calf pairs and completing paternity exclusions for each calf. We are also engaged in confirming the presence or absence of a supernumerary chromosome marker found in this population for the more recently sampled animals from which blood was drawn. These data taken together provide the basis for a comprehensive investigation of social unit structure in the Sarasota Bay dolphin community. In no other bottlenose dolphin community studied has it been possible to individually profile an entire community over generations with both genetic analyses and long-term behavioral observations.

**Need for Additional Work:** With the genetic data now in hand, we are in a position to begin to integrate our long-term behavioral data and the genetic data, leading to the development of peer-reviewed scientific manuscripts on the social unit (stock) structure.

#### **1f. Population Dynamics Modeling Workshop**

**Project Synopsis:** The plan called for working with four pre-eminent scientists in the field of marine mammal population dynamics to test their theoretical approaches to population modeling against our own empirical dolphin data. The work was expected to result in unique scientific publications, provide direction for future approaches to population management, and possibly lead to a symposium, perhaps associated with a biennial marine mammal conference.

**Participants:** Randall Wells and other SDRP staff, Robert Lacy, Chicago Zoological Society

**Accomplishments and Findings:** This project has been successful in leading to the objective and rigorous definition of a population unit and selection of an appropriate dataset for which abundance and vital rate values are currently being developed. While not leading to the collaborative tests initially planned, the approach to defining the population unit has been reviewed and is supported by several pre-eminent scientists in this area (Robert Lacy (CZS), Barb Taylor (NMFS), Jay Barlow (NMFS), Paul Wade (NMFS) and Ailsa Hall (SMRU)). The data are now being prepared for publication in peer-reviewed scientific journals, and they have been applied to current conservation issues. Robert Lacy (Job 1g) has been participating in analyses, and in August 2008 computer projections using Sarasota Bay dolphin population parameters and Lacy's Vortex computer simulation program were applied to help evaluate the impacts of removals of bottlenose dolphins from island populations, at an IUCN workshop in Samoa.

We have defined the unit for which we are measuring abundance and vital rates geographically, including those animals that use "Sarasota Bay" (as specifically defined) on a regular basis – that is, they have been seen in a broad area including and surrounding Sarasota Bay, and more than half of their sightings have been within our defined Sarasota Bay study area. The selected time period is 1993 to the present, as this is the period for which we have comparable year-round survey effort (following Wells' move to Sarasota in 1992).

Preliminary analyses indicate that 96% of the dolphins in the study area are identifiable, meaning that our work essentially constitutes a census of the dolphins frequenting the area. Considering a total of 341 dolphins that met the criteria for inclusion during 1993-2007, the annual abundance has increased from 142 individuals in 1993 to 178 in 2002, with a subsequent decline to 166 individuals in 2007. During 2006, about 2% of the regular users died from recreational fishing gear ingestion, an unprecedented phenomenon. Analyses are underway to examine changes in abundance and vital rates such as population growth, mortality, fecundity, immigration and emigration relative to environmental factors such as the state-wide commercial net fishing ban in 1995 that likely increased food availability in Sarasota Bay and elsewhere, and a series of red tides including the severe event of 2005 that depleted dolphin prey fish in the bay.

**Need for Additional Work:** Now that an objective, quantitative approach to defining the population unit has been accepted, analyses of abundance and vital rates are underway that should lead to manuscripts for peer-reviewed scientific journals. Once they clear the peer-review process, Sarasota Bay abundance estimates will be provided to NMFS for incorporation into

Stock Assessment Reports. Continuity and consistency in data collection will be needed to be able to test hypotheses regarding the role of environmental factors in variability in abundance and vital rates, as natural, opportunistic experiments present themselves.

### **1g. Vortex Software Enhancement for Population Viability Analyses**

**Project Synopsis:** CZS Conservation Biologist Robert Lacy enhanced the capabilities of his ground-breaking population viability analysis (PVA) software, Vortex, through additional programming. Capabilities were added to allow: (1) modeling of complex social structures, in which breeding, survival, and dispersal can be specified to be influenced by the social environment; (2) linkage to a new epidemiological model of disease (Outbreak), so that impacts of disease can be included in the model of population change; (3) linkage to Geographic Information System (GIS) data on landscape patterns; and (4) inclusion of a newly developed model of animal movements.

**Participants:** Robert Lacy, Chicago Zoological Society

**Accomplishments and Findings:** This project has been completed successfully. We have applied to software to Sarasota Bay dolphin data to investigate the potential impacts of removals through human interactions and commercial collections. The enhancements to the Vortex software will soon be used to help us refine population projections for the dolphins under various scenarios of changing habitat and population structure. Specific accomplishments included: (1) The capability of the software to model population structure was implemented via a component that allows specification of individual attributes (such as social status or group membership), definition of processes that can change those attributes over time, and influences of those attributes on demographic rates. (2) The linkage of Vortex to the epidemiological program (Outbreak) was completed, and work is underway on providing more detailed documentation and testing. (3) Linkages to GIS models are still being developed, with additional expertise, funding, and testing being provided by the GIS laboratory of the Smithsonian Institution's Conservation and Research Center. (4) The linkage to a model of spatial movements of animals (Spatial, developed by JP Pollak of VisualBiosystems) was completed in May 2005. Graduate students working at the Smithsonian Institution have been working on testing and documenting this "meta-model." (5) An option in Vortex to allow the population projections to be started with a known population (numbers, age, sex, social group membership, and even pedigree), rather than with randomly assigned individuals, was completed in March 2005. (6) In the process of making enhancements to Vortex, we added the capability to link Vortex to almost any other modeling program, with the programs sharing data via xml files that describe the system. The current distributed versions of Vortex and Outbreak are available at [www.vortex9.org](http://www.vortex9.org).

Preliminary Vortex modeling of the Sarasota Bay dolphins suggested that in the absence of human interactions, the Sarasota Bay dolphin population would increase slowly to a level between 150 and 200 dolphins. With human interactions (fishing gear entanglement and ingestion, boat strikes, etc.), the population would decline. If the elevated level of mortality from recreational fishing gear experienced in 2006 continues, then there will be a rapid decline of the population, to extinction. Modeling of commercial live-capture removals of dolphins from the Sarasota Bay population showed that removals in excess of about 1.5% per year would lead to extinction. This level is less than what has previously been permitted by NMFS. Extrapolation

of these analyses to island populations of Indian Ocean bottlenose dolphins in places such as the Solomons suggested that current levels of removal are likely unsustainable.

**Need for Additional Work:** Manuscripts will be produced describing projections from known or estimated levels of human interactions with dolphin populations.

## **Job 2. Health Assessment and Biomarkers of Environmental Contaminants and Their Effects**

**Project Synopsis:** In response to increasing concerns about the health of coastal bottlenose dolphin populations as a result of large-scale mortality events since the 1980's, we initiated a program to monitor the health of the dolphins of Sarasota Bay, and have been working with NMFS scientists and others to develop an approach to health assessment that could be applied to evaluation of health risks for bottlenose dolphin populations in Sarasota Bay and elsewhere. We have also taken an active role in attempting to understand the effects of environmental contaminants on bottlenose dolphin health and reproduction. To this end, we participated in the International Whaling Commission's 3-year "Pollution 2000+ Program" to identify biomarkers of exposure and effects of contaminants. We worked closely with Dr. Teri Rowles, the Coordinator of the NMFS Marine Mammal Health and Stranding Response Program, in the design, implementation, analysis, and interpretation of findings from efforts conducted under this Job.

### **2a. Health Assessment and Contaminant Studies.**

**Project Synopsis:** Efforts continued under this initiative to monitor the health of the Sarasota dolphin community. This was accomplished by briefly capturing, examining, sampling, and releasing Sarasota Bay bottlenose dolphins (conducted under NMFS Scientific Research Permit No. 522-1569, and more recently, 522-1785). Over the period of this initiative we worked with Dr. Rowles and others to refine our initial blood parameter-based model for scoring dolphin population health (Wells et al. 2004).

#### **2a.1. Seasonal Sarasota Bay Dolphin Health Assessment and Contaminant Sampling**

**Project Synopsis:** Seasonal variations have been documented in mortality patterns, health assessment scores, field metabolic rates, blubber depth, and body condition for Sarasota Bay's resident bottlenose dolphins. Findings to date suggest that local dolphins may enjoy better health in winter months than in summer (Wells et al. 2004). We examined the hypothesis that at least part of this difference may be related to blubber dynamics resulting in seasonal variations in contaminant concentrations in blubber and other tissues. We addressed the question of whether contaminants sequestered in blubber as its thickness increases in fall/winter are released when blubber thickness decreases in spring/summer, exposing organs to adverse effects from these toxicants. We conducted capture, sample, mark, and release operations during additional capture-release sessions through February and June 2005. Subsequent sampling through 2008 was accomplished through support of other sources. Capture-release operations also provided opportunities for additional research on dolphin physiology, hearing abilities, and communication of relevance to dolphin conservation, at no additional cost to the project.

**Participants:** Randall Wells, Michael Scott, Blair Irvine and other SDRP staff, Teri Rowles, NMFS, Lori Schwacke, NOS, Ailsa Hall, SMRU, John Kucklick, NIST, Jenn Yordy, NIST, Colleen Bryan, NIST, Stephen Christopher, NIST, Todd O’Hara, UAF, Victoria Woshner, Derek Muir, Environment Canada, Magali Houde, U. of Guelph, Jay Sweeney, Dolphin Quest, Ann Pabst, UNCW, Bill McLellan, UNCW, Andrew Westgate, UNCW, Erin Meagher, UNCW, Michelle Barbieri, UNCW, Laela Sayigh, UNCW, Vincent Janik, SMRU, Carter Esch, UNCW, David Mann, USF, Mandy Cook, USF.

**Accomplishments and Findings:** Excellent progress has been made on this project, above and beyond the work supported by the NMFS grant. The following capture-release health assessment and contaminant sampling sessions were conducted, with NMFS sponsoring the fall/winter sessions, while Dolphin Quest sponsored the spring/summer sessions (Table 1).

<u>SESSION DATES</u>	<u>NO. DOLPHINS SAMPLED: FALL/WINTER</u>	<u>NO. DOLPHINS SAMPLED: SPRING/SUMMER</u>
June 3-6, 2002		18
November 4-6, 2002	5	
February 3-5, 2003	3	
June 2-10, 2003		13
February 2-10, 2004	18	
June 2-11, 2004		13
January 31- February 4, 2005	9	
June 1-10, 2005		10
June 10-16, 2006		19
May 1-9, 2008		<u>13</u>
<b>TOTAL</b>	<b>35</b>	<b>86</b>

Table 1. Schedule of capture-release sessions for dolphin health assessment.

**Health Assessment** – Basic clinical data from health assessments have been incorporated into ongoing databases used for a variety of purposes. Hematology and blood cytology data have been used as reference values for comparison across populations (Schwacke et al. in press) and for captive dolphins (Wells in review, Ruiz et al. in press). The reference values have been compared to health assessment data from populations recently involved in Unusual Mortality Events in the Florida panhandle in order to try to identify parameters that appear out of the ordinary. Preliminary examination suggests that eosinophil counts in some panhandle dolphins appear elevated, leading to investigation of factors that might lead to eosinophilia as possible explanations for the UMEs.

Building on initial work by Wells et al. (2004), examination of hematology and clinical blood chemistry profiles compiled over a 14-year period was conducted to evaluate individual, seasonal, and inter-annual variation (Hall et al. 2007). Significant variability at all three of these levels for many of the parameters complicates the use of these blood parameters for potential quantitative measures of population health through a simple scoring system (Wells et al. 2004). The study also confirmed the importance of using the same blood laboratories across studies, as there was significant inter-laboratory variability (Hall et al. 2007).

Health assessment operations yielded data on dolphin body condition and occurrence of skin lesions relative to occurrence of environmental events such as red tides that could influence health. Unusual skin lesions apparent on some animals early in 2006 following a severe red tide outbreak were fully healed by the time of health assessments in June 2006. Possible impacts of

the severe 2005 red tide may have been indicated during 2006 health assessments by the significantly lower weights of 2-year-old calves as compared to previous sampling events, and lower weights for the mothers and adult males as well. Weights of dolphins measured during 2008 health assessments, more than 1.5 years after the most recent red tide, were back within normal range. The opportunity provided by health assessments to examine scars from injuries of known and unknown causes provided crucial information for evaluation of the seriousness of the injuries, for extrapolation to other situations such as offshore fisheries (Wells et al. in press).

Sarasota Bay dolphin health assessments contributed significantly to the body of knowledge about microorganisms (bacteria, fungi, viruses) that may be pathophysiological concern. Our abilities to assess health risks to free-ranging dolphin populations, to treat live-stranded or captive dolphins, and to evaluate the risks of disease transmission between humans and dolphins have suffered from a lack of basic information on microorganisms associated with “normal”, presumably healthy free-ranging individuals. Buck et al. (2006) summarized samples collected over a 13-year period from free-ranging bottlenose dolphins off Florida, Texas, and North Carolina in order to try to resolve this data gap. Blowhole and anal/fecal samples yielded 1,871 bacteria and yeast isolates, including 85 different species or groups of organisms. The following represented >50% of organisms recovered: vibrios, unidentified pseudomonads, *Escherichia coli*, *Staphylococcus* spp., and a large group of non-fermenting Gram negative bacteria. *Vibrio alginolyticus* and *V. damsela* were the most commonly recovered bacteria and were dominant in both anal/fecal and blowhole samples. Many organisms occurred sporadically in dolphins sampled repeatedly, but some were regularly associated with a given individual and may indicate a carrier state. Vibrios were common, but some geographic variability in the presence of these and other organisms was noted. Potential pathogens of significance to humans and other animals were recovered. These could be transmitted from animal to animal and thus distributed in different environments by transient dolphins, with subsequent health implications.

The detection or occurrence of other potential pathogens was also described for Sarasota Bay dolphins, including *Bartonella* spp. (Harms et al. 2008), *Helicobacter cetorum* (Harper et al. 2003), and a novel parainfluenza virus (Venn-Watson et al. 2008).

**Environmental Contaminants** – The project was involved extensively in research on environmental contaminants in coastal bottlenose dolphins, and contributed significantly to increasing our understanding of the occurrence and impacts of both inorganic and organic contaminants. The project initiated or participated in five primary analytical efforts, described in this section and below:

- 1. Organochlorine analyses**, especially PCB congeners and pesticides, performed by Jennifer Yordy and John Kucklick at the National Institute of Standards and Technology (NIST) laboratory in Charleston, SC.
- 2. Development of biomarkers** of organochlorine exposure, performed by Joanna Wilson of Woods Hole Oceanographic Institution and Victoria Tornero and colleagues at the University of Barcelona, as part of the IWC Pollution 2000+ Programme.
- 3. Emerging perfluoroalkyl compounds** and hydroxylated PCB analyses, performed by Magali Houde and Derek Muir of Environment Canada and the University of Guelph.
- 4. Measurement of baseline concentrations of trace elements** in dolphin blood and skin, performed by Colleen Bryan and Steven Christopher at the National Institute of Standards and Technology (NIST) laboratory in Charleston, SC.

**5. Functional relationships of mercury and selenium** concentrations in dolphin blood and skin, performed by Todd O'Hara of the University of Alaska, Fairbanks, and Victoria Woshner.

**1. Organochlorine analyses:** Bottlenose dolphins are long-lived, fish-eating marine mammals that are at or near the top of the food web in coastal ecosystems. As a result, they are vulnerable to accumulating heavy burdens of persistent organohalogen contaminants (POCs). POCs are man-made compounds that are used in industry, agricultural and domestic settings with uses such as electrical insulating fluids, flame retardants and insecticides. They were released into the environment before their toxicities and environmental consequences were fully understood; however, we now know that POCs can persist in the environment for decades and can have effects ranging from cancer to effects on the immune system. POCs found in dolphins now include banned compounds such as the polychlorinated biphenyls (PCBs) and chlorinated pesticides (e.g., DDT) which were banned from production in the 1970s, as well as compounds in active use such as the polybrominated diphenyl ethers (PBDEs).

All of these compounds can be readily detected in the bottlenose dolphins of Sarasota Bay, FL. The Sarasota Dolphin Research Program provided an unparalleled opportunity for assessing contaminant exposure at the population level as many of these parameters are known for the resident bottlenose dolphins. To assess the degree of POC exposure and potential health effects in the Sarasota Bay bottlenose dolphin population, approximately 195 blubber, blood and milk samples were collected for contaminant analysis during live capture and release health assessments since June 2000. In addition, the primary Sarasota dolphin prey, including pinfish, pigfish and mullet were analyzed for 81 POC compounds to assess the role of diet on dolphin contaminant exposure.

Preliminary analyses of individual POC compounds provided the basis for describing patterns of accumulation and depuration relative to life history parameters (Wells et al. 2003, 2005), and contributed to development of risk assessments (Schwacke et al. 2002, Hall et al. 2006). Wells et al. (2003, 2005) described accumulation of POCs throughout the lives of males, to levels an order of magnitude or more greater than that proposed for the threshold for health or reproductive effects (Schwacke et al. 2002), and perhaps contributing to a shorter life span than for females. Concentrations in females decline once they begin lactating, and remain below the threshold (Wells et al. 2005). First-born calves receive higher doses than subsequent calves, perhaps contributing to the higher mortality for first-born calves. Schwacke et al. (2002) suggested that reproductive success, especially for primiparous females, is being severely impaired by chronic exposure to PCBs in Sarasota Bay, Beaufort, NC, and Matagorda Bay, TX. Hall et al. (2006) proposed that PCB concentrations might be depressing the potential population growth rate for Sarasota Bay dolphins.

POCs do not occur in dolphins as isolated single compounds but rather as mixtures with dozens of other POCs. It is well known that contaminant mixtures may have toxicities differing significantly from those found for single compounds. Therefore, knowledge regarding mixture composition is important for understanding the link between contaminant burden and adverse health effects in marine mammals. Many factors influence how dolphins are exposed to contaminant mixtures, including diet, age, reproductive maturity and nutritional state.

To date, this collective data set indicates that the mixture of POCs in a dolphin changes throughout its lifetime. Contaminant profiles in both young and older juvenile animals (ages 1.5-10 years) are highly reflective of a milk diet, despite the gradual shift to a fish-based diet that starts as early as 18 months old. In male dolphins, profiles appear to shift with increasing age to contain higher proportions of compounds that dolphins are unable to break down and excrete. In contrast, female bottlenose dolphins experience dramatic shifts in POC mixture profiles upon reaching reproductive maturity, when compounds are selectively offloaded into her milk and passed to her first-born calf. Since POC mixtures differ in toxicity, there may be health implications associated with the shifts in contaminant profiles throughout the lifetime of Sarasota bottlenose dolphins. Future plans include assessing the toxicity of these mixtures using *in-vitro* bioassays. These data may also be used in the future to assess potential health effects in other wild cetacean populations.

Work is now focused on preparing manuscripts on the above data. The goal of the first manuscript is to provide an initial assessment of the individual variation of organohalogen mixtures within the Sarasota Bay bottlenose dolphin community. Concentrations of organohalogens were measured in the blubber and milk of bottlenose dolphins of known age, gender and reproductive maturity. Principal components analysis (PCA) will be used to examine the influence of life history on contaminant mixtures and identify potential factors responsible for observed differences between individuals. The manuscript will be ready for submission in late 2008. These manuscripts will form the basis of Jennifer Yordy's dissertation through the Medical University of South Carolina. In addition, Yordy has determined that blood samples can be used in the place of blubber samples to monitor body burdens of contaminants, opening the door to much wider-spread sampling because of the much-reduced invasiveness of sampling for contaminants.

Data from this study complemented other studies on pollutant metabolites and health indicators. The grant-supported portion of this project was successfully completed, with significant additional work provided by NIST at no charge to the project. Personnel from NIST also participated in the June 2006 and May 2008 samplings in Sarasota Bay. Samples were collected using the established protocols and are now archived by NIST in Charleston.

**2. Development of biomarkers:** See Job 2b.1 below.

**3. Emerging perfluoroalkyl compounds:** The objective of this project was to assess the concentrations of two groups of emerging environmental contaminants, perfluorinated compounds and hydroxylated metabolites of polychlorinated biphenyls, in bottlenose dolphins during 2002-2005. Plasma, urine, and milk were collected from live-captured dolphins and analyzed for both contaminant groups. Water, sediment, zooplankton, and fish samples were also collected in Sarasota Bay in order to investigate the potential bioaccumulation/biomagnification of perfluorinated compounds in the bottlenose dolphin food web. Temporal and spatial trends of perfluorinated compounds were investigated. In addition, relationships between life history and reproductive parameters of animals and burden of perfluorinated compounds in plasma were evaluated. This project was completed successfully with the successful defense of Magali Houde's dissertation in Spring 2006 (Houde 2006), and the publication of four peer-reviewed scientific papers resulting from the work (Houde et al. 2005, 2006a, 2006b, 2006c).

Houde (2006) investigated polyfluoroalkyl compounds (PFCs), polychlorinated biphenyls (PCBs) and hydroxylated-PCB metabolites (OH-PCBs) in live-captured and released bottlenose dolphins from the Western Atlantic and the Gulf of Mexico. Spatial trends in plasma contamination were observed for PFCs, PCBs, and OH-PCBs with the highest concentrations detected in plasma of dolphins sampled around Charleston, South Carolina (Houde et al. 2005, 2006a). The detection of fluorotelomer carboxylic acids in dolphin plasma supported the hypothesis that fluorotelomer alcohols could be responsible for the long-range transport of PFCs. The concentrations of PFCs in plasma were not associated with gender but decreased with the age of animals (Houde et al. 2006b). Sexually immature and developing calves were indeed more contaminated than mothers. The reproductive history of females was found to be associated with PFC concentrations and PFCs were found in milk of dolphins. These chemicals were detected in all organs of dolphins analyzed. The lack of temporal or seasonal trends in the concentrations suggested a continuous exposure of dolphins to these contaminants. The detection of PFCs in urine indicated excretion through the urinary system. Seawater and sediment from South Carolina and western Florida were contaminated with PFCs and the bioaccumulation and biomagnification of numerous PFCs in the bottlenose dolphin food web was observed (Houde et al. 2006c). The results have also shown that, compared to the whole body burden estimation, using plasma or liver concentrations in dolphins tended to overestimate the biomagnification of PFCs.

Houde (2006) demonstrated through measurements of PCBs and OH-PCBs in plasma that these chemicals are major environmental contaminants in dolphins. The profiles of PCB and OH-PCB contamination were similar within contaminant groups among locations suggesting similar biotransformation processes, albeit at different intensities. The analysis of plasma has shown that a wide spectrum of OH-PCBs is found in blood of bottlenose dolphins. However, only around 20% of these could be identified by comparison to authentic standards, suggesting that OH-PCB concentrations are likely underestimated in samples.

**4. Measurement of baseline concentrations of trace elements:** Recent unusual mortality events have led to concerns for the health of bottlenose dolphin populations in the southeastern U.S. Exposure to high concentrations of some trace elements can impact animal health. Trace elements were examined by NIST for Sarasota Bay dolphins in order to develop an index for comparison with other populations for health assessments (Bryan et al. 2007). Whole blood ( $n=51$ ) and skin ( $n=40$ ) samples were collected through capture/release events during 2002-2004. Samples were analyzed for Al, V, Cr, Mn, Cu, Zn, As, Se, Rb, Sr, Mo, Cd, and Pb by inductively coupled plasma mass spectrometry and Hg via atomic fluorescence spectrometry. Trace element concentrations (wet mass) in skin were 2 to 45 times higher than blood, except Cu was approximately 1.5 times higher in blood. Statistically strong correlations ( $p<0.05$ ) were found for V, As, Se, Rb, Sr, and Hg between blood and skin demonstrating that these tissues can be used as effective non-lethal monitoring tools. The strongest correlation was established for Hg ( $R^2 = 0.94$ ) and levels in both blood and skin were above the threshold at which detrimental effects are observed in other vertebrate species. Trends based on sex were identified for Hg in blood and skin and Pb in skin. Age class trends were established for V, As, and Hg in blood and V, Cu, Rb, and Hg in skin. Seasonal trends were observed for V, Zn, As, Rb, and Sr in blood and Mn, Cu, Zn, Rb, Cd, and Pb in skin. The baseline concentrations and trends established in this study will serve as an index for comparison for future monitoring of this population and for other

coastal bottlenose dolphin populations (Bryan et al. 2007). Successful completion of this project contributed to Colleen Bryan's Master's thesis through the College of Charleston (Bryan 2006).

**5. Functional relationships of mercury and selenium:** See Job 2b.3 below.

**Physiology** - The capture-release process for health assessment leveraged opportunities to investigate aspects of bottlenose dolphin physiology of relevance to understanding health and their equilibrium with their environment. Bottlenose dolphins in Sarasota Bay are exposed to water temperatures that range from about 57° F to more than 90° F in the summer, leading to potential health issues from the need to conserve body heat in winter and overheating in summer from an inability to dump heat to an environment that is close to body. A complex interplay of seasonal changes in blubber thickness and thermoregulatory mechanisms involving vascular processes allow these animals to survive through extremes at both end of the temperature spectrum.

Bottlenose dolphin thermoregulation was examined by examining heat flow through the body wall and appendages for restrained animals, and relating these values to water temperature (Meagher 2008, Meagher et al. 2002, 2008), providing a more complete understanding of how dolphins conserve and lose heat. Thermal images of restrained and free-ranging dolphins showed that changes in integumentary and vascular insulation likely account for the stability of the differential in temperature between the dorsal fin and the water, and the protection of core body temperature across seasons (Barbieri 2005, Barbieri et al. in revision). Westgate et al. (2007) developed a non-invasive, suction-cup mounted dorsal fin package for recording both convective and conductive heat loss from the dorsal fins of dolphins released from capture-release operations.

Blubber is a complex structure, with both costs and benefits to the dolphins. Predicted thicknesses for insulation in the cold water scenario would potentially lead to problems for yearling dolphins, by creating too much buoyancy and interfering with diving; thus these animals face potential thermoregulatory risks at this time in their life (Noren and Wells in press). In a related issue, it was determined that juvenile dolphins do not complete the development of blood and its capacity to store oxygen until after weaning, creating yet another limitation to their diving abilities (Noren et al. 2002).

**Acoustics** – In recent years, concerns have increased around the world about the potential effects of noise on cetaceans. Bottlenose dolphins rely on sound for communication, navigation, and foraging, meaning that hearing is one of their primary sensory modalities. Both natural and anthropogenic noise in the marine environment could mask the ability of free-ranging dolphins to detect sounds, and chronic noise exposure could cause permanent hearing losses. Taking advantage of the availability of wild dolphins for testing during health assessments, Mandy Hill investigated the hearing abilities of Sarasota Bay bottlenose dolphins by using non-invasive auditory evoked potential techniques for part of her dissertation research through the University of South Florida. This represents the first population-level survey of dolphin hearing abilities that has ever been conducted. Hill (2006) found that there was considerable individual variation, up to 80 dB between individuals, in hearing abilities. There was no relationship between age, sex, or PCB load and hearing sensitivities. Hill successfully defended her dissertation, and is preparing manuscripts for publication.

**Communication** – Recordings of sounds produced by Sarasota Bay bottlenose dolphins during capture-release efforts since 1975, combined with recordings of the same individuals under free-ranging circumstances, have contributed greatly to our understanding of the development, stability, nature, and importance of signature whistles (Sayigh et al. 2007). These individually-specific whistles develop early in life, and may be modeled in part on signature whistles of other community members (Fripp et al. 2004). Strong evidence supports the idea that signature whistles function as identifiers for individual recognition, and serve as contact calls when dolphins are out of visual contact with one another (Watwood et al. 2005, Cook et al. 2004, Quintana-Rizzo et al. 2006). Signature whistle features may also reflect the strength of social bonds, with paired males showing some degree of convergence of signature whistles (Watwood et al. 2005). In recent years, playbacks of recorded whistles and synthetic whistle components have helped to define the individual identifier function of whistles as well as the most important components of the whistles for conveying identity information (Janik et al. 2006). Increases in rates of whistle production have been found to potentially indicate stress (Esch 2007, Esch et al. in review), and this is manifested in apparent responses to approaching vessels (Buckstaff 2003, 2004). These findings about the importance of signature whistles to the dolphins of Sarasota Bay raise concerns about increased anthropogenic noise in the environment interfering with important functions of social groups by masking communications.

**Need for Additional Work:** Much of the work for this Job would benefit from continuation. It is important to monitor trends over time in health and body condition parameters, contaminant burdens, and hearing abilities, as factors influencing these topics are changing. A number of tissue samples have been archived at NIST, awaiting support for analysis. With data available from samples analyzed to date, it should be possible to develop a manuscript that begins to examine seasonal and inter-annual patterns for organohalogen contaminant concentrations, building on Wells et al. (2005).

## **2a.2. Charlotte Harbor Dolphin Health Assessment and Contaminant Sampling**

**Project Synopsis:** We planned to conduct capture, sample, mark, and release operations in Charlotte Harbor for comparison with similar sampling and measurements in Sarasota Bay. Charlotte Harbor was considered to be a relatively “clean” site that would aid in refinement of a health assessment model as well as in elucidation of the role of environmental contaminants in dolphin health and reproduction.

**Accomplishments and Findings:** This capture-release project was cancelled due to logistical concerns and the recognized need for additional contaminant analyses, following discussions in November 2002 with our NMFS Grant Officer. The funding from this Job was redirected toward environmental contaminant analyses (Job 2a.1, above), including preliminary analyses of biopsy dart blubber samples collected from Charlotte Harbor dolphins as part of this project.

## **2a.3. Health Assessment Modeling**

**Project Synopsis:** We worked with NMFS scientists and others to develop a preliminary approach to health assessment that could be applied to evaluation of health risks for bottlenose dolphin populations in Sarasota Bay and elsewhere (Wells et al. 2004). The original model,

incorporating 19 blood parameters of clinical importance, suffered from several weaknesses. We have been working with NMFS and SMRU colleagues to explore new parameters and approaches to see if a more accurate and predictive model is possible.

**Participants:** Randall Wells, SDRP, Ailsa Hall, SMRU, and Lori Schwacke, NOS

**Accomplishments and Findings:** Examination of hematology and clinical blood chemistry profiles compiled over a 14-year period was conducted to evaluate individual, seasonal, and inter-annual variation (Hall et al. 2007). Significant variability at all three of these levels for many of the parameters complicates the use of these blood parameters for potential quantitative measures of population health through a simple scoring system as attempted previously by Wells et al. (2004). Geographical variation in blood parameters was also investigated, in order to establish baseline reference values (Schwacke et al. in press). Generalized ranges based on a large sample size will be useful for identifying parameters which could potentially vary across sampling sites, and help for identifying parameters outside of normal ranges during unusual mortality events (Schwacke et al. in press). In addition to basic clinical blood data, analyses of immune function data relative to sample handling time as well as intrinsic variables (such as sex, age and condition) and extrinsic variables such as contaminant exposure levels were performed, including the construction of a number of statistical mixed effects models to investigate significant predictors of immune variables (Hall et al. 2006).

**Need for Additional Work:** Additional data from more sites and across time would allow for refinement of reference ranges and increase sensitivity for identification of parameters of interest from blood sampling during unusual mortality events.

#### **2a.4. Effects of Biotoxins on Marine Mammals**

**Project Synopsis:** PhD student Spencer Fire (University of California, Santa Cruz), investigated the effects of brevetoxin (neurotoxin released by the dinoflagellate, *Karenia brevis*) on bottlenose dolphins through examination of brevetoxin in tissues of live and stranded dolphins, examination of dolphin prey, and behavioral monitoring of dolphins during red tide events. The main objectives of the project involved tissue analysis of field-exposed fish preyed on by bottlenose dolphins, to detect brevetoxins, analysis of *T. truncatus* tissues from stranding necropsies to detect brevetoxins, toxin analysis of urine, blood and fecal samples taken from dolphins during live captures concurrent with a *Karenia brevis* bloom, and investigating if any behavioral avoidance of red tide exists in the dolphins.

**Participants:** Spencer Fire and other SDRP staff

**Accomplishments and Findings:** This project was completed successfully with the successful defense of Spencer Fire's doctoral dissertation in October 2006. Fire (2006) presented data describing brevetoxin activity detected in dolphin tissues, gastric samples, blood and excreta, and in prey fish commonly consumed by Sarasota Bay dolphins. In the sample set, 84% of dolphin carcasses recovered during *K. brevis* blooms had detectable brevetoxin activity, with values reaching as high as 2900 ng PbTx-eq/g (Fire et al. 2007). Over 50% of dolphin carcasses recovered during non-bloom conditions also tested positive for brevetoxin activity. For live dolphins, 65% of individuals sampled during a bloom tested positive for brevetoxin activity (Fire et al. in press a). All specimens of dolphin prey fish sampled during a bloom had detectable

levels of brevetoxin activity (Fire et al. 2008). Over 90% of fish sampled during non-bloom conditions tested positive for brevetoxin activity, a finding also noted by Naar et al. (2007). Fire (2006) presented descriptions of behavioral responses of dolphins to the presence of elevated levels of *K. brevis* in the Sarasota Bay area. Data suggested that during a bloom, dolphins may avoid areas of high *K. brevis* cell densities. In addition, dolphins observed during a bloom had higher rates of chuffing (explosive respiration) than dolphins observed during non-bloom conditions. Supplemental work by Gannon et al. (in revision b) showed that the dolphins of Sarasota Bay changed their distributions and increased their group size in apparent response to the severe 2005 red tide.

**Need for Additional Work:** Comparable observations during subsequent red tide events would provide further opportunities for testing the relationships described from the work performed for this Job.

## **2b. Biomarker Studies**

**Project Synopsis:** This Job involved continuing collection of samples for the collaborative international study to identify biomarkers of environmental contaminants and their effects in bottlenose dolphins and harbor porpoises, the IWC Pollution 2000+ Program, followed by sample and data analyses and manuscript preparation. Blubber samples were collected for measurement of PCB concentrations, porphyrins, luciferase, enzyme induction, and vitamin A. Blood samples were to be analyzed for PCB concentrations, porphyrins, luciferase, thyroid hormones, inflammatory mediators, leukocyte subpopulations, lymphocyte function, CBC, vitamin A, reproductive hormones, and serum chemistry. In addition to the biomarkers identified for the IWC program, Dana Wetzel and John Reynolds of Mote Marine Laboratory explored the potential of using fatty acids as biomarkers. Todd O'Hara and Victoria Woshner began examining functional aspects of relationships between mercury and selenium in dolphin tissues.

### **2b.1. IWC Pollution 2000+ Program**

**Project Synopsis:** Collection of samples for the IWC Pollution 2000+ Program was originally planned to continue through June 2002, followed by sample and data analyses and manuscript preparation. Blubber samples were to be used for measurement of PCB concentrations, porphyrins, luciferase, enzyme induction, and vitamin A. Blood samples are being analyzed for PCB concentrations, porphyrins, luciferase, thyroid hormones, inflammatory mediators, leukocyte subpopulations, lymphocyte function, CBC, vitamin A, reproductive hormones, and serum chemistry.

**Participants:** Randall Wells and other SDRP staff, Teri Rowles, NMFS, Alex Aguilar, Victoria Tornero and Asuncion Borrell, U. of Barcelona, Joanna Wilson, WHOI/MIT, Peter Reijnders, Alterra

**Accomplishments and Findings:** In spite of changes to the funding structure for this project, it has been completed successfully with the production of a set of reports and manuscripts. The IWC failed to provide funding for the third and final year of sample collection for their "Pollution 2000+" program to identify biomarkers of environmental contaminants and their effects in bottlenose dolphins and harbor porpoises. What little funding was available for 2002

was directed toward analysis of samples collected during the first two years of the program, and remaining funds are being used for harbor porpoise sample analyses. During 2000-2001 we obtained samples from 47 dolphins for the IWC biomarker program. These samples were distributed to the appropriate laboratories for analyses, and most of the analyses were completed, and reports and manuscripts have been generated (as listed below). Blubber contaminant residue concentration data demonstrated expected patterns of organochlorine accumulation in males, and depuration in females, with concentrations of PCBs typically in excess of those for which human health concerns would be expressed (Wells et al. 2004, 2005). The Steering Committee met in Sorrento, Italy in June 2004 to discuss plans for completing the program. Further analyses involving bottlenose dolphins, including sending archived samples of blood and urine to Spain for completion of analyses, along with additional blubber samples from Charlotte Harbor biopsy darting for characterizing contaminant loads in a “clean site” could only be conducted if additional funding became available from the IWC; this did not occur. In light of this status, Phase I of Pollution 2000+ was summarized and final reports were prepared (Tornerio et al. 2005, Reijnders et al. 2006, Hall et al. 2006, Woshner et al. 2006, Wilson et al. 2006, 2007). The utility of retinoids as biomarkers of contaminant exposure remains in question (Tornerio et al. 2007), but findings supported the value of cytochrome P4501A1 expression in the integument as a biomarker of exposure to aryl hydrocarbon receptor agonists such as PCBs (Wilson et al. 2007).

Beyond the IWC program, we continued research on biomarkers and the effects of environmental contaminants on dolphin health and reproduction. To this end, we continued to collect samples during capture-release efforts for measurement of contaminants in blubber, blood, and milk, and for biomarkers in the forms of enzyme induction activity and immunohistochemistry, reproductive hormones, immunological factors, and fatty acids. Archived samples and current samples have been analyzed by colleagues in the US and Canada, at laboratories with known production histories and QA/QC. Organochlorines were analyzed by doctoral student Jenn Yordy and Dr. John Kucklick of the National Institute of Standards and Technology, in Charleston (reported above). Perfluorinated hydrocarbons were examined by doctoral student Magali Houde and Dr. Derek Muir at the University of Guelph, and Environment Canada, in Ontario, Canada (reported above).

The results of previous University of Utah organochlorine contaminant analyses of archived dolphin plasma collected during 1988 through 1999 were evaluated by Dr. Ailsa Hall relative to QA/QC concerns. The resulting set of data within acceptable limits provides a unique time series for evaluation of patterns of accumulation, depuration, and seasonal variations in circulating contaminants. These results provided additional rationale for the seasonal health assessment and sampling program funded through NMFS (Job 2a.1 above).

**Need for Additional Work:** A number of samples remain to be analyzed to evaluate additional potential biomarkers, and the utility of these biomarkers could be tested through comparison with samples from “clean” sites”.

## **2b.2. Fatty Acids as Biomarkers**

**Project Synopsis:** Mote Marine Laboratory staff members began to explore the potential of using fatty acids as biomarkers for harmful algal blooms. This component of the work involved examination of fatty acid profiles and attempted to assess whether relationships exist between

cause of death categories or disease conditions and those profiles. The optimal way to assess this question involves use of hepatic fatty acids; note that liver biopsies can not be collected during the dolphin health examinations and were only available from carcasses.

**Participants:** Dana Wetzel and John Reynolds

**Progress to Date:** This project has been completed successfully. The fatty acid composition of the livers of bottlenose dolphins were assessed to investigate whether individuals dying due to exposure to harmful algal blooms (specifically brevetoxin and saxitoxin) possessed distinctive fatty acids that could be used as biomarkers of such exposure. In an earlier study, the PIs demonstrated that hepatic fatty acid composition in manatees (*Trichechus manatus*) was highly correlated with exposure to brevetoxin, the extent where the presence of a small suite of fatty acids appeared to be diagnostic of "red tide mortality" in that species (i.e., it was a reliable biomarker). In the current study, liver samples from 38 individual dolphin carcasses of various body lengths, both sexes, and multiple causes of death were acquired; complete analyses were conducted for 14 samples. The results for the 14 fully-analyzed dolphin liver samples indicated that: a) 39 hepatic fatty acids have been found; b) 19 fatty acids were present in all samples; c) the most abundant hepatic fatty acids were 18:0, 16:0, 20:4n6, 18:1n9, 16:1n7, and 22:6n3; d) saturated fatty acids were most common followed by (in order) polyunsaturates and mono-unsaturates; e) principal components analyses (PCA) clarified that samples may be clustered by cause of death; and f) two of the fatty acids considered most indicative of brevetoxin exposure in dead manatees (i.e., 14:1n5 and 22:1n9) were also found in a number of dolphin livers. Although analyses need to be completed for more animals, the results suggested that hepatic fatty acid composition may be a useful biomarker of exposure to harmful algal blooms for bottlenose dolphins.

**Need for Additional Work:** The preliminary work funded through this project involved analysis of fewer than half of the available samples. Additional samples would potentially refine the conclusions that could be drawn from this work.

### **2b.3. Mercury and Selenium in Dolphin Tissues**

**Project Synopsis:** Mercury (Hg) has been identified as an environmental contaminant of concern for many animals, including bottlenose dolphins. We are examining Hg in bottlenose dolphin skin epidermis as an indicator of concentrations in other tissues and as a means of exploring some of the biological processes involving Hg and selenium (Se). We will compare our findings to other studies of cetacean species, including the work reported above by NIST.

**Participants:** Todd O'Hara, U. of Alaska- Fairbanks, Victoria Woshner

**Accomplishments and Findings:** This project was completed successfully. All chemical, biochemical and histological analyses were completed, one manuscript has been published (Woshner et al. 2008) and another is nearly completed (Woshner, V., D. Miller, R. Wells, C. Willetto, K. Knott and T. O'Hara. In preparation. Epidermal histomorphology and histopathology related to various biological variables of live-captured and released bottlenose dolphins from Sarasota Bay, Florida). Blood and epidermal (outer layer of skin) samples from free-ranging bottlenose dolphins captured and released during health assessments in Sarasota Bay were evaluated for concentrations of mercury (Hg), selenium (Se), stable isotopes of carbon (C) and nitrogen (N) to address diet patterns of the dolphins, and blood glutathione peroxidase activity (antioxidant enzyme dependent on selenium) in conjunction with routine hematology

(examination of blood) and serum chemistry panels (for example, measures of kidney, liver and other organ system function). We evaluated these multiple endpoints to determine if: 1) mercury could be producing adverse effects (toxicosis), 2) selenium may not be present in adequate chemical forms and amounts (deficiency), or 3) both (mercury toxicosis and selenium deficiency – a possible nutrient and chemical interaction). Major objectives were to: 1) quantify and describe relationships among mercury, selenium, glutathione peroxidase, and stable isotopes of C and N in blood and epidermis; 2) elucidate major parameters that influence blood mercury and glutathione peroxidase activity; 3) relate measures of tissue mercury, selenium, and glutathione peroxidase to specific ecological, hematological, morphological, or life history parameters, including season, sex, age, and trophic level.

As expected, mercury in both epidermis and blood is almost exclusively methylmercury (the more bioavailable and toxic form as compared to inorganic forms). Epidermal concentrations of mercury and selenium reflect (correlate with) their respective amounts in blood, albeit at several times blood concentrations of mercury (epidermis has been proposed as a pathway for excretion of mercury as it sheds from the animal). The strong association between blood mercury and serum selenium, in conjunction with a lack of significant correlation between blood mercury and glutathione peroxidase, implies that a substantial proportion of blood mercury is affiliated with another selenium-containing moiety or is related to recent dietary intakes (for example, trophic level, intensive fish consumption). It is well known that mercury and selenium interact (selenium can make mercury less toxic) and we need to better understand how increased exposure to mercury may increase the demand for dietary selenium. Circulating blood mercury concentrations correlated with serum selenium concentration. Age and the trophic level in the food web were found to be important considerations for the status of mercury and selenium. Current selenium concentrations in Sarasota Bay dolphins appear adequate for maintenance of blood glutathione peroxidase activity. However, dolphins appear to be subject to seasonal variability which might render them more vulnerable to toxic effects of mercury at some times of the year. We need to further assess the condition of these dolphins and their prey fish. This interaction could also be important for rehabilitation efforts to consider as well (for example, adequate selenium levels for dolphins).

### **Job 3. Ecological Relationships (previously referred to as Feeding Ecology)**

**Project Synopsis:** We used NMFS support to develop a better understanding of the feeding ecology of Sarasota Bay dolphins, by refining our understanding of specific prey preferences, by identifying the relative trophic position of these dolphins, by quantifying spatial and temporal relationships between the dolphins and their prey, and by identifying feeding habitats of importance to the animals. We attempted to apply and refine recently-developed molecular approaches -- stable isotope and fatty acid analyses -- to define the dolphin's relative trophic level and to identify of the species and size classes of fish consumed by the dolphins. We initiated quantitative measurements of prey in the field for comparison to dolphin habitat use patterns. This information facilitates evaluation of the implications to dolphin populations of changes in resource availability.

### **3a. Using Stomach Content Analyses and Stable Isotopes To Understand Feeding Ecology**

**Project Synopsis:** The goal of this study was to better understand the feeding ecology of Sarasota Bay bottlenose dolphins through the examination of stomach contents of stranded animals and through analyses of stable isotopic ratios of carbon and nitrogen (a longer-term indicator of feeding history) in tissues of both dolphin and their fish prey. This was supplemented with analyses of sulfur, performed at no cost to this project. The concept behind this technique is that the isotopic composition of tissues of the predator may be similar to, or deviate by a known amount from, that of their prey. Tissues of both predator (dolphins: remnants of teeth collected for age determination from live animals and muscle from stranded dolphins) and their prey (four species of fish) were collected for stable isotope analysis.

**Participants:** Nelio Barros, Randall Wells, SDRP, Peggy Ostrom, Michigan State University, Craig Stricker, USGS-Denver

**Accomplishments and Findings:** In this study, we evaluated the utility of stable isotopes as a potential tool for assessment of bottlenose dolphin (*Tursiops truncatus*) population association in west central Florida. We analyzed the C, N, and S stable isotopic composition ( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$ , respectively) of collagen extracted from teeth of stranded dolphins representing four potential populations. The results have been summarized in a draft manuscript: Barros, N.B., P.H. Ostrom, C.A. Stricker and R.S. Wells. In prep. Stable isotopes differentiate dolphin populations off west central Florida. Animals of known origin and history from the Sarasota Bay (SB) and Charlotte Harbor (CH) estuaries served as a means to ground truth the approach. Dolphins from the adjacent coastal and offshore waters of the Gulf of Mexico constituted the other two populations with no known history. The four populations were significantly different for each of the three isotopes.  $\delta^{13}\text{C}$  data indicated that estuarine dolphins utilizing seagrass ecosystems could be differentiated from Gulf of Mexico and offshore populations. Average  $\delta^{15}\text{N}$  values of dolphins from the Gulf of Mexico and offshore were higher than dolphins from estuaries, consistent with differences in the trophic level of prey observed in stomach content analyses and known prey base. The  $\delta^{34}\text{S}$  values showed clear distinctions between dolphins from estuaries, the Gulf of Mexico and offshore. It was not possible to differentiate among estuarine populations using  $\delta^{34}\text{S}$ , yet sample size was limiting for Charlotte Harbor. These findings support a multi-isotope approach because it clearly provides much more information regarding dolphin foraging ecology, habitat affinity, and population association than any one isotope alone.

As part of a doctoral dissertation project, PhD student Glenn Dunshea of the University of Tasmania examined dolphin fecal samples for prey DNA and determined that these kinds of analyses can lead to confounded results and should be used with caution (Dunshea et al. 2008).

**Need for Additional Work:** Additional samples should be analyzed for  $\delta^{34}\text{S}$ . This was not possible for the current project due to USGS equipment problems.

### **3b. Using Fatty Acid Signatures To Identify Feeding Preferences**

**Project Synopsis:** The use of chemical techniques to provide insight into ecological or biological questions has expanded rapidly in such areas as foraging ecology, where the presence in tissues of certain residues (e.g., unusual fatty acids) or isotopes suggest trophic level or even precise feeding preferences. The initial goals for using fatty acid signatures included the following: a) to begin to develop a reference library of fatty acids found in prey species of

bottlenose dolphins in west, central Florida; and b) to start to assess fatty acid constituents of dolphin blubber taken from various locations in a dolphin's body.

**Participants:** Dana Wetzel, John Reynolds, Mote Marine Laboratory

**Accomplishments and Findings:** This project was completed, and a manuscript has been submitted for publication on two occasions, but it has not yet been accepted. Accomplishments include (a) initiating a fatty acid library for some fish commonly consumed by dolphins; (b) assessing fatty acid constituents of blubber from a number of adult dolphins, including lactating females; c) assessing fatty acid constituents of blubber from 2-3 year old calves attending captured females; and d) assessing fatty acid constituents of milk from lactating females.

The chemical analyses of dolphin prey have not been used to assess dolphin foraging because those analyses do not include several species consumed by dolphins (i.e., statistical analyses would suffer because dolphin blubber could reflect fatty acids of prey not included to date in the study).

**Need for Additional Work:** The collection and analysis of representatives of additional dolphin prey species is necessary to be able to perform a statistical analysis of dolphin blubber and prey to begin to assess foraging.

### **3c. Relating Dolphin Habitat Use and Population Parameters to Prey Distribution and Abundance**

**Project Synopsis:** We investigated the abundance and fine-scale distribution of dolphin prey in Sarasota Bay and the adjacent nearshore waters of the Gulf of Mexico. Detailed information on prey availability is facilitating interpretation of patterns of habitat selection exhibited by the dolphins, is providing insight into methods of measuring habitat quality for coastal bottlenose dolphins, and is allowing us to evaluate the ecological effects that red tide blooms have on coastal bottlenose dolphins. The field techniques used to sample prey density included purse seining and passive acoustic recording.

**Participants:** Damon Gannon, Elizabeth Berens, Sandy Camilleri, Katie Brueggen and other SDRP staff

**Accomplishments and Findings:** The portion of the project originally funded by this grant was successfully completed several years ago, and manuscripts are being developed from the resulting data, including analyses of the distribution and abundance of dolphin prey relative to dolphin distributions. With additional support from other sources, this project has continued to document and examine the changes in dolphin prey abundance and fish community structure as the study area recovers from severe red tide events (summer 2005 and 2006). Fish sampling has occurred in five habitats every summer and winter from summer 2004 to summer 2007. Winter sampling in 2007/2008 was limited to three habitats previously identified through this work as important for dolphin prey species. Summer 2008 sampling targeted seagrass habitat only in an effort to increase sample size in this important prey habitat. Through 30 March 2008, 869 purse seine sets have been made, which captured/released 305,785 fishes of 132 species.

We compared the relative abundances of dolphin prey available to estimates of prey use at closely matching spatial and temporal scales. Electivity indices and a statistical analysis of dolphin prey selection indicate that resident dolphins in Sarasota Bay are selective predators at

the population level. Specifically, they significantly select for soniferous (i.e. noise-producing fish) prey species and against nonsoniferous prey species. Dolphins selected against the highly abundant pinfish (*Lagodon rhomboides*) and all members of the Gerridae, Clupeidae, and Sparidae at the species and family levels (Berens-McCabe, E.J., D. Gannon, N. Barros, and R.S. Wells. In prep. Prey selection in a resident common bottlenose dolphin (*Tursiops truncatus*) community in Sarasota Bay, Florida). These findings support previous work that hypothesized that coastal bottlenose dolphins use passive listening to locate noise-producing prey (Gannon et al. 2005).

Although not one of the original objectives of the Job, this project has provided the first quantitative documentation of the impacts of red tides on estuarine fish communities (Gannon et al. in revision b). Since the beginning of fish sampling in 2004, two red tide periods have occurred within Sarasota Bay. A severe and prolonged red tide occurred from February to December 2005 and covered much of the west coast of Florida. A moderate red tide occurred from mid August to December 2006. Our previous sampling showed that in general the relative abundance of fish decreased 10% when non-red tide periods and red tide periods from 2004-2007 were compared. Previous work suggested that soniferous (noise-making) fishes, such as pigfish and spotted seatrout, were selected and consumed by dolphins using passive listening (Gannon et al. 2005). These soniferous species decreased 85-97% in relative abundance when non-red tide periods and red tide periods were compared. Additionally, species diversity dropped and the fish community shifted from dominance by bottom-dwelling species like pinfish, mojarra, silver perch, and pigfish toward dominance by pelagic filter feeders, such as the Atlantic thread herring.

Within the past 20 years, Sarasota Bay has been affected by red tide every 2-3 years. It is important to understand the cyclical nature of red tide effects on the west coast of Florida, including both the effects that red tide has on fish and dolphin populations and also the recovery of the ecosystem. Since the 2005 and 2006 red tide events, we have seen a complete recovery of the Sarasota Bay estuarine fish community. In the seagrass habitat, the overall relative abundance of fishes rebounded by summer 2006 (132% over 2004 levels) despite the moderate red tide during the late summer months. However abundances were mainly due to the red-tide-induced shift in community structure, resulting in an increase in the abundance of pelagic filter feeding fish. Species richness remained 86% of 2004 levels. By 2007, Sarasota Bay had experienced two red tides and fish abundance in the seagrass habitat was 75% of 2004 levels. Currently, most fish species have reached or exceeded their 2004 pre-red-tide abundance levels. Fish caught per purse seine set in the seagrass habitat increased by 40% from summer 2004 to summer 2008 and soniferous fishes increased by 138% within that same period. Overall species richness reached and exceeded pre-red-tide levels by summer 2007 and the fish community structure has shifted back to being dominated by bottom-dwelling species once again. Our data indicate that some species take longer to recover from red tide than others, fish abundance on its own may not be an accurate reflection of the estuarine community's recovery, and both species richness and soniferous dolphin prey abundance may take up to two years to recover to pre-red-tide levels. While we have determined that severe red tides greatly decrease fish abundance, decrease species composition, and shift fish community structure, within two years most species recovered to or exceed pre-red tide abundance levels and measures of species richness.

**Need for Additional Work:** A number of important questions remain, including investigating the effects of red tides on the growth rate, body condition, reproductive rates, habitat selection,

and behavior of both fishes and dolphins. To address these questions, continued, consistent fish sampling in Sarasota Bay is needed.

### **3d. Predation Pressure on Dolphins in Sarasota Bay**

**Project Synopsis:** It is important to understand the potential impacts of natural as well as anthropogenic threats to bottlenose dolphin populations. To this end, we planned to investigate the distribution, movements, and abundance of large sharks as potential dolphin predators in Sarasota Bay. We attempted to catch, tag, and release large sharks in Sarasota Bay. Sonic tags were employed, to try to develop a picture of habitat use, which could then be related to concurrent patterns of habitat use by dolphins.

**Participants:** Aaron Barleycorn and other SDRP staff, Michelle Heupel and other Mote Marine Laboratory staff

**Progress to Date:** This project was completed, with evidence suggesting that large sharks are not common in the Sarasota Bay area. Initiation of field work was delayed for a variety of reasons. Red tides during the summers of 2005 and 2006 precluded capture of large sharks in Sarasota Bay. Field work was conducted in August-September of 2007. Over the course of 9 field days, 280 baited drum lines were set resulting in three sharks (two nurse sharks and one bull shark) being caught and released. The nurse sharks were not considered potential dolphin predators and were released without tracking tags. The 230 cm bull shark was given an ultrasonic tag and released. Unfortunately the tracking boat lost the shark soon after release, and despite several attempts over the next few weeks, the signal was never reacquired. The near-total consumption by sharks of dolphin FB230 during July 2007, severe shark bite wounds on adult female FB63 leading to her death and subsequent shark scavenging in October 2008, and a non-fatal attack by a large bull shark on a college student swimming at night in Sarasota Bay on 15 August 2007 indicate the presence of large predatory sharks at least occasionally, but low catch rates per unit effort suggest that they do not frequent interior portions of the home range of the Sarasota Bay resident dolphins.

**Need for Additional Work:** Continuation of this project at this time would likely not be cost-effective due to the apparent low abundance of large sharks currently using Sarasota Bay, but if shark abundance increases, the research could be very important for understanding dolphin habitat use patterns.

### **Job 4. Human Interactions**

**Project Synopsis:** The dolphins of Sarasota Bay are impacted by a variety of human activities, including but not limited to: pollution, entanglement in recreational, and to a lesser extent, commercial fishing gear, collisions with boats, disturbance from vessels, high-speed boat races, habitat degradation from coastal development, construction activities and dredging, and human feeding. Ongoing efforts attempted to evaluate the relative impacts of these human interactions and report them to the National Marine Fisheries Service and the scientific community, through our health assessment program, through monitoring and field observations, through experiments, and through close interactions with Mote Marine Laboratory's Stranding Investigations Program (e.g., Nowacek et al. 2001, Buckstaff 2004, Cunningham-Smith et al. 2006, Wells et al. in press,

Buckstaff et al. in revision). Our efforts to understand, evaluate, and mitigate human activities as possible continued to evolve through the duration of the initiative.

#### **4a. Effects of Watercraft Activity on the Acoustic Behavior of Bottlenose Dolphins**

**Project Synopsis:** There are many forms of man-made noise that contaminate the marine environment. Preliminary studies on cetaceans concentrating on the effects of some types of anthropogenic noise have raised concerns regarding the potentially deleterious effects on these acoustically-sensitive animals. Elevated background noise levels produced by man-made noise may prevent detection of sounds important to cetaceans, such as calls from conspecifics and echolocation pulses, interfering with communication, prey detection, navigation, and detection of predators. For her Master's research through the University of California, Santa Cruz, Kara Buckstaff assessed the effects on the acoustic properties of vocalizations such as whistle frequency range, whistle rate, and whistle duration during opportunistic and experimental boat approaches. We also deployed non-invasive digital acoustic data logger devices on dolphins for controlled vessel approaches. These devices, known as DTAGs, were the latest versions of onboard systems for recording levels of sound at the animal itself, along with the animals' heading, depth, and degrees of pitch and roll.

**Participants:** Kara Buckstaff and other SDRP staff

**Accomplishments and Findings:** This project was successfully completed when Kara Buckstaff successfully defended her Master's thesis in May 2003, and published her findings (Buckstaff 2004). Nowacek et al. (2001) reported that the resident bottlenose dolphins of Sarasota Bay were exposed to a vessel passing within 100 m approximately every six minutes during daylight hours. Building on this finding, Buckstaff (2003) investigated the circumstances under which boat traffic may impact the acoustic behavior of this dolphin community, specifically looking at changes in whistle structure and production. Acoustic recordings were obtained during focal animal follows. Signature whistles from 19 dolphins were examined to look at changes in frequency range and duration. Overall whistle rate was measured for before, during, and after opportunistic boat approaches and compared to periods when no boats were present. Received boat noise levels were calculated for boats at their closest approach. Signature whistle duration and frequency range did not change significantly relative to boat approaches. Dolphins whistled significantly more before the presence of a boat compared to during and after approaches. Whistle rate at the onset of a boat approach was significantly greater than when no boats were present. Planing boats were 18 dB louder than background levels. Whistle repetition may be an effective way to reduce signal degradation and enhance communication in a noisy environment (Buckstaff 2004).

**Need for Additional Work:** More work is needed to determine the threshold level at which watercraft become detectable to dolphins, and at what level a response is elicited.

#### **4b. Effects of Vessel Traffic on Dolphin Habitat Use and Behavior**

**Progress Synopsis:** Patterns of habitat use by Sarasota Bay dolphins have shifted markedly in recent years. In particular, bottlenose dolphins have begun using the deeper waters of Sarasota Bay to a greater extent than in past years, including shifts by some individuals that previously frequented shallower bays, and immigration on both a seasonal and year-round basis by some

individuals. Human activities have been implicated as potential contributors to these changes, including: (1) increases in vessel traffic and changes in the kinds of vessels used, (2) increased prey fish availability as a result of the net ban, and (3) decreases in the numbers of predatory sharks due to over-fishing. In actuality, the reasons behind the shift are likely not simple, and each of these factors and others may play a role. As described above, we intend to examine the relationships between prey abundance and distribution and dolphin habitat use. To better understand the potential contribution of boat traffic to these shifts, we plan to examine patterns of habitat use and behavior by Sarasota Bay dolphins relative to the distributions and activities of vessels during the same period. Previous research conducted by SDRP has demonstrated short-term behavioral and acoustical responses of bottlenose dolphins to vessel traffic. High levels of boat traffic can lead to injuries or disturbance, as manifested by changes in behavior and use of acoustic signaling. Additionally, yearly increases in Sarasota Bay vessel activity have created an underwater acoustic environment that is significantly different from the acoustic environment even thirty years ago. Temporal and spatial variation in vessel traffic and noise may produce differences in habitat use, habitat selection, and behavioral patterns of resident dolphins. This project will serve as Christine Shepard's doctoral dissertation through the University of California, Santa Cruz.

**Participants:** Christine Shepard, University of California, Santa Cruz

**Accomplishments and Findings:** This project was cancelled, as Christine Shepard changed her graduate research direction, moving out of dolphin research and into an unrelated graduate program in May 2005. She has provided us with all of her data.

**Need for Additional Work:** The need for this project continues. It would make an excellent graduate student project.

#### **4c. Tag Development for Studies of Human Impacts on Cetaceans**

**Project Synopsis:** We worked to improve upon the design and attachment method of a non-invasive digital recording tag (DTAG) developed by Woods Hole Oceanographic Institution for application to a variety of marine mammals, including dolphins, large whales, and manatees. The project included aspects that would improve attachment duration and data collection as well as analyses of data collected during test deployments. Improved attachment of the tag enhances applicability to a variety of human impact issues. DTAGs were tested in the field to investigate impacts of vessel approaches on dolphins in Sarasota Bay.

**Participants:** Doug Nowacek, SDRP/MML/FSU, Kara Buckstaff, SDRP, Mark Johnson, WHOI

**Accomplishments and Findings:** The first part of this job, modification to DTAG design was completed successfully, with a design that should be ready for the field. Tests performed at Disney's Living Seas have identified an improved attachment design for the DTAG that would prolong the suction-cup attachment period on dolphins under a variety of conditions. Data analyses for the second part of the Job, publishing results of DTAG deployments relative to boat traffic, have been mostly completed, and a draft manuscript is nearing completion.

DTAG data analyses to assess behavioral responses to controlled vessel approaches have been completed. Heading, pitch, roll, and acoustic data were processed for controlled

(experimental) vessel approaches, as well as opportunistic approaches and control periods. Acoustic data showed that received noise levels of experimental approaches were significantly louder than control periods at all frequencies between 125-8000 Hz. However, when differentiated between slow and fast types of experimental boat approaches there were no significant differences in received levels. There was a significant difference among boat speeds classified as plane, plow, idle, and underway. Planing boats were the loudest for frequencies between 125-2000 Hz, however plowing boats were loudest for higher frequencies of 4000-8000 Hz. Inboard engines had received levels louder than outboard engines at all distance and speeds over all frequencies. There was a general trend of a decrease in received level as distance increased for all frequencies.

Fluke stroke rates were compared between control periods (when no boats or just the observation platform were present) and experimental approaches at the closest point of approach. Fluke stroke rate was significantly elevated during experimental approaches as compared to control periods (1.047 Hz cf. 0.825 Hz,  $p = 0.006$ ). Experimental approaches were divided into slow and fast categories (defined as plowing or planing approaches). There was no significant difference in fluke stroke rate between these approach types ( $p = 0.1708$ ). There was also no significant difference between fluke stroke rates compared between experimental and opportunistic approach types ( $p = 0.4523$ ). Fluke stroke rates were compared between opportunistic approaches and control periods, and similar to the experimental approaches, there was a significant increase in stroke rate during opportunistic approaches (1.061 Hz cf. 0.825 Hz,  $p = 0.003$ ).

Further analyses were conducted to elucidate which factors, such as closest distance of boat approach and associated peak received level (RL) contribute to a dolphin's response. Water depth of the dolphin at the closest distance of a boat approach was also considered. On average, peak RL was loudest for dolphins that responded, however there is only a significant difference between response and control conditions ( $p = 0.00007$ ) as well as no response and control conditions ( $p = 0.0004$ ), and not between response and no response conditions. A significant correlation was noted between dolphin depth and the distance of closest approach; dolphins were at deeper depths during closer approaches ( $p = 0.017$ ).

Principal component analysis (PCA) was used to determine which variables had the most influence on eliciting a response. Peak frequency was included as a variable as well as the original three factors: dolphin depth, peak RL, and closest distance of approach. The goal in generating a PCA was to highlight any potential relationships between the four variables for responders and non-responders, however, a clear distinction was not made as to which variables caused a response. Forthcoming results from dolphin heading rate analysis can possibly highlight which of these variables, in conjunction with the fluke stroke rate results, were most influential in determining what causes a dolphin to respond to an approaching boat.

**Need for Additional Work:** Tests on bottlenose dolphins in Sarasota Bay throughout the period of evolution of the DTAG have contributed to enhancing and expanding the applicability of this tag to a variety of marine mammals, including dolphins, whales, and manatees. It is expected that the package will continue to evolve, with decreased size, increased attachment period, and enhanced sensor capabilities. As research questions and testing needs arise, Sarasota Bay will provide opportunities or needs for DTAG deployment.

## **Job 5. Graduate Student Research**

**Project Synopsis:** Graduate student research has played, and will continue to play, an important role in the development of research involving Sarasota Bay dolphins. Graduate students typically demonstrate exceptionally high levels of dedication and quality of research that benefits any research effort in which they are engaged. In addition, they may also disseminate our methodologies and conservation and research philosophies as they advance through their careers. Students were accepted through the Ocean Sciences Department of the University of California, Santa Cruz (UCSC, where Wells serves as adjunct Professor), through the Woods Hole Oceanographic Institution MIT Joint Program (PhD students, sponsored by P. Tyack), through the Biology Department of the University of North Carolina, Wilmington (where Wells serves as adjunct Professor), or through individual arrangements with universities such as the University of South Florida, in St. Petersburg, the University of California, Davis, and the University of Guelph.

The following students are engaged in, or have completed, graduate research involving our program. Graduate student involvement included field research in Sarasota Bay, analysis of samples provided from Sarasota Bay dolphins, or significant input or guidance provided by SDRP staff. The student projects receiving direct support from this grant have been described above under specific Jobs. During the grant period, the program contributed to the successful completion of eight doctoral dissertations, with four others continuing and making good progress beyond the end of the grant. The grant contributed to the successful completion of ten Master's theses, with one more scheduled to be completed by the end of 2008.

### **Doctoral Dissertations**

- Completed: Owen, E.C.G. 2003. The reproductive and ecological functions of the pair bond between allied, adult male bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay. University of California, Santa Cruz.
- Completed: Watwood, S. L. 2003. Whistle use and whistle sharing by allied male bottlenose dolphins (*Tursiops truncatus*). Ph. D. dissertation, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution, Woods Hole, MA 227 pp.
- Completed. Houde, M. 2006. Emerging organohalogen contaminants in bottlenose dolphins (*Tursiops truncatus*). University of Guelph. 317 pp.
- Completed. Quintana-Rizzo, E. 2006. Group fission-fusion dynamics and communication in the Bottlenose Dolphin (*Tursiops truncatus*). University of South Florida. 166 pp.
- Completed. Cook, M.L.H. 2006. Behavioral and auditory evoked potential (AEP) hearing measurements in odontocete cetaceans. University of South Florida. 134 pp.
- Completed. Fire, S.E. 2006. Effects of *Karenia brevis* blooms on wild coastal bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. Ocean Sciences Dept., University of California, Santa Cruz.
- Completed. Thayer, V.G. 2007. Life history parameters and social associations of female bottlenose dolphins (*Tursiops truncatus*) off North Carolina, USA. Duke University.
- Completed. Meagher, E. 2008. Thermoregulation of bottlenose dolphins. Biology Dept. University of North Carolina, Wilmington.
- In progress. McHugh, K. Behavior of juvenile bottlenose dolphins in Sarasota Bay. University of California, Davis.
- In progress. Yordy, J. Organohalogen concentrations in bottlenose dolphin tissues. Medical University of South Carolina.

- In progress. Simard, P. The abundance and distribution of cetaceans on the west Florida shelf: a synoptic study based on acoustics, visual surveys and remote sensing. University of South Florida.
- In progress. Balmer, B.C. Environmental influences on bottlenose dolphin (*Tursiops truncatus*) community structure and dynamics in the Southeastern United States. University of North Carolina, Wilmington.
- Withdrew from program. Shepard, C. University of California, Santa Cruz.

### **Masters Theses**

- Completed: Sellas, A.B. 2002. Population structure and group relatedness of bottlenose dolphins (*Tursiops truncatus*) in the coastal Gulf of Mexico using mitochondrial DNA and nuclear microsatellite markers. MS Thesis, University of California, Santa Cruz.
- Completed: Urian, K.W. 2002. Community structure of bottlenose dolphins (*Tursiops truncatus*) in Tampa Bay, Florida, USA. MS thesis, University of North Carolina, Wilmington. 26 pp.
- Completed: Buckstaff, K. C. 2003. Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. MS thesis, University of California, Santa Cruz. 37 pp.
- Completed: Weiss, J. 2003. Importance of matrilineal lines in the transmission of foraging specializations of bottlenose dolphins (*Tursiops truncatus*) within Sarasota Bay, Florida. MS thesis Duke University.
- Completed: Klatsky, L. 2004. Satellite-monitored movements and diving behavior of Bottlenose dolphins, *Tursiops truncatus*, in offshore waters of the northwest Atlantic Ocean near Bermuda. MS thesis. San Diego State University, San Diego, CA
- Completed: Barbieri, M. 2005. Assessment of mechanisms of physiological and behavioral thermoregulation in bottlenose dolphins (*Tursiops truncatus*) in Sarasota, Florida. MS thesis. University of North Carolina, Wilmington.
- Completed: Esch, C. 2006. Whistles as potential indicators of stress in bottlenose dolphins (*Tursiops truncatus*). University of North Carolina, Wilmington.
- Completed: Bryan, C. 2006. Non-lethal monitoring of trace elements in bottlenose dolphins. MS thesis. College of Charleston.
- Completed: Balmer, B.C. 2007. Seasonal abundance, site-fidelity, and utilization areas of bottlenose dolphins in St. Joseph Bay, Florida. MS thesis. University of North Carolina, Wilmington. 61 pp.
- Completed. Tyson, R. Abundance of bottlenose dolphins (*Tursiops truncatus*) in the Big Bend of Florida, St. Vincent Sound to Alligator Harbor. Florida State University.
- In progress: Powell, J. Depredation by bottlenose dolphins. University of South Florida, College of Marine Science, St. Petersburg, FL.
- Suspended: Monaco, L. Defining success for cetacean rehabilitation. Western Illinois University.

### **Job 6. Dissemination of Information**

**Project Synopsis:** Dissemination of information resulting from the research supported by this project was an inherent objective of the work. Dissemination took the form of peer-reviewed scientific publications, doctoral dissertations, Master's theses, scientific presentations, and invited public and university lectures.

**Participants:** SDRP staff, students, collaborating investigators

**Accomplishments and Findings:** The following lists includes the manuscripts that have been published, accepted for publication (in press), submitted for publication (in review), or are being revised following review (in revision), and the presentations made since the inception of the project. Doctoral dissertations and Master's theses are listed under Job 5. (above). Hard copies and electronic pdf files of all publications accompany this report.

The project demonstrated a high level of scientific productivity. The project resulted in, or contributed to, more than 60 published peer-reviewed scientific journal articles or technical reports, with another 11 currently "in press" and ten more submitted to journals and undergoing review. The research team made more than 150 scientific presentations, and more than 60 public and university lectures on topics related to the project.

## **6a. Manuscripts and Reports**

### **In Press**

- Balmer, B. C., R. S. Wells, S. M. Nowacek, D. P. Nowacek, L. H. Schwacke, W. A. McLellan, F. S. Scharf, T. K. Rowles, L. J. Hansen, T. R. Spradlin, and D. A. Pabst. In press. Seasonal abundance and distribution patterns of bottlenose dolphins (*Tursiops truncatus*) near St. Joseph Bay, Florida, USA. *Journal of Cetacean Research and Management*.
- Fire, S.E., Z. Wang, L.J. Flewelling, J. Naar, M.S. Henry, R. H. Pierce, and R. S. Wells. In press. Florida red tide and brevetoxins: association and exposure in live resident bottlenose dolphins (*Tursiops truncatus*) in the eastern Gulf of Mexico, USA. *Marine Mammal Science*.
- Gannon, D.P. In press. Passive acoustic techniques in fisheries science: a review and prospectus. *Transactions of the American Fisheries Society*.
- Noren, S.R. and R.S. Wells. In press. Postnatal blubber deposition in free-ranging common bottlenose dolphins (*Tursiops truncatus*) with considerations to buoyancy and cost of transport. *Journal of Mammalogy*.
- Quintana-Rizzo, E. and R.S. Wells. In press. Unusual behavior of an adult female bottlenose dolphin (*Tursiops truncatus*) toward a non-related dead neonate. *Aquatic Mammals*
- Ruiz, C., H.H. Nollens, S. Venn-Watson, L.G. Green, R.S. Wells., M.T. Walsh, E. Chittick, J.F. McBain and E.R. Jacobson. In press. Baseline circulating immunoglobulin G levels in managed collection and free-ranging bottlenose dolphins (*Tursiops truncatus*). *Developmental and Comparative Immunology*.
- Schwacke, L.H., A.J. Hall, F.I. Townsend, R.S. Wells, L.J. Hansen, A.A. Hohn, G.D. Bossart, P.A. Fair and T.K. Rowles. In press. Hematology and clinical blood chemistry reference intervals for free-ranging common bottlenose dolphins (*Tursiops truncatus*) and variation related to geographic sampling site. *American Journal of Veterinary Research*.
- Wells, R. S. In press. Dolphins and porpoises. *In: J.H. Steele, S.A. Thorpe, and K. K. Turekian (eds.), Encyclopedia of Ocean Sciences – on line. Oxford, UK: Elsevier.*
- Wells, R.S. In press. Identification methods. *In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds., Encyclopedia of Marine Mammals. Second Edition. Elsevier, Inc., San Diego, CA.*
- Wells, R.S. and M.D. Scott. In press. Common bottlenose dolphins (*Tursiops truncatus*). *In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds., Encyclopedia of Marine Mammals. Second Edition. Elsevier, Inc., San Diego, CA.*

Wells, R.S., J.B. Allen, S. Hofmann, K. Bassos-Hull, D.A. Fauquier, N.B. Barros, R.E. DeLynn, G. Hurst, V. Socha and M.D. Scott. In press. Consequences of injuries on survival and reproduction of common bottlenose dolphins (*Tursiops truncatus*) along the west coast of Florida. *Marine Mammal Science*.

### **In Review/Revision**

- Barbieri, M.M., W. A. McLellan, R. S. Wells, J. A. Blum, S. Hofmann, J. Gannon, and D. A. Pabst. In review. Thermoregulatory responses of a resident community of bottlenose dolphins (*Tursiops truncatus*) to seasonal changes in environmental temperature in Sarasota Bay, FL, U.S.A..
- Brueggen, M.K. and D.P. Gannon. In review. Responses of chorusing male spotted seatrout (*Cynoscion nebulosus*) to acoustic cues associated with predators. (submitted to *Copeia*).
- Buckstaff, K.C., R.S. Wells, J.G. Gannon, and D.P. Nowacek. In revision. Responses of bottlenose dolphins to construction and demolition of coastal marine structures. *Aquatic Mammals*.
- Esch, H.C., L.S. Sayigh, J.E. Blum, and R.S. Wells. In review. Whistles as potential indicators of stress in bottlenose dolphins (*Tursiops truncatus*). *Journal of Mammalogy*.
- Fauquier, D.A., M.J. Kinsel, M.D. Dailey, G.E. Hurst, N.B. Barros, M.K. Stolen, R.S. Wells and F.M.D. Gulland. In review. Prevalence and pathology of lungworm (*Halocercus* sp.) infection in bottlenose dolphins in southwest Florida. Submitted to *Diseases of Aquatic Organisms*.
- Gannon, D.P. and J.G. Gannon. In review. Can passive acoustic methods be used to assess trends in abundance of soniferous fishes? *Canadian Journal of Fisheries and Aquatic Sciences*.
- Gannon, D.P., E.J. Berens, S.A. Camilleri, J.G. Gannon, M.K. Brueggen, A. Barleycorn, V. Palubok, G.J. Kirkpatrick and R.S. Wells. Accepted pending revision a. Effects of *Karenia brevis* harmful algal blooms on nearshore fish communities in southwest Florida. *Marine Ecology Progress Series*.
- Gannon, J.G., R.S. Wells, J.B. Allen, D.P. Gannon, S. Hofmann, G.J. Kirkpatrick and V. Palubok. Accepted pending revision b. Apparent sub-lethal effects of a harmful algal bloom on bottlenose dolphins in Sarasota Bay, Florida. *Marine Ecology Progress Series*.
- Loughlin, T., R. S. Wells, L. Cunningham and N. Gales. In review. Marking and capturing. Chapter 2 *In: I, Boyd, D. Bowen and S. Iverson (eds.), Marine Mammal Ecology and Conservation: A Handbook of Techniques*. Oxford University Press.
- Mancia, A. G. W. Warr, J. Almeida, A. Veloso, R. S. Wells and R. W. Chapman. In review. What can the transcriptome tell us about populations of free-ranging bottlenose dolphins, *Tursiops truncatus*? *Molecular Ecology*.
- Quintana-Rizzo, E., R.S. Wells, and J.J. Torres. In revision a. Defining a group in species with fluid relationships. *Animal Behaviour*.
- Quintana-Rizzo, E. and R.S. Wells. In revision. Social and ecological factors affecting group fission-fusion in wild female bottlenose dolphins (*Tursiops truncatus*). *Animal Behaviour*.
- Quintana-Rizzo, E., R.S. Wells, and D. Mann. In review b. Echolocation and whistle use during fission-fusion events in wild bottlenose dolphins (*Tursiops truncatus*). *Canadian Journal of Zoology*.
- Urian, K.W., S. Hofmann, R.S. Wells, and A.J. Read. Accepted pending revisions. Fine-scale population structure of bottlenose dolphins, *Tursiops truncatus*, in Tampa Bay, Florida. *Marine Mammal Science*.

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## Presentations

In addition to the publications, the following presentations (oral or poster) have been made to scientific audiences since the inception of the project. These presentations were made by program staff, students, and collaborators from other institutions.

- Harms, C.A. R.G. Maggi, E.B. Breitschwerdt, C.L. Clemons-Chevis, M. Solangi, P.A. Fair, L.J. Hansen, A.A. Hohn, G.G. Lovewell, W.A. McLellan, D.A. Pabst, T.K. Rowles, L.H. Schwacke, F.I. Townsend, and R.S. Wells. 2008. *Bartonella* species detection in captive and stranded versus healthy free-ranging dolphins and porpoises in the southeastern United States. Southeast and Mid-Atlantic Marine Mammal Symposium, 28-30 March, Charleston, SC.
- Mancia, A., G.W. Warr, J. Almeida, R. Wells, A. Veloso, and R.W. Chapman. 2008. Location, location, location ..... or what can the transcriptome tell us about populations of free-ranging bottlenose dolphins, *Tursiops truncatus*? Southeast and Mid-Atlantic Marine Mammal Symposium, 28-30 March, Charleston, SC.

- McHugh, K.A., S. Hofmann, J.B. Allen, M.D. Scott, and R.S. Wells. 2008. Factors influencing variation in age at independence for free-ranging bottlenose dolphin calves in Sarasota Bay, Florida. Southeast and Mid-Atlantic Marine Mammal Symposium, 28-30 March, Charleston, SC.
- Powell, J.R., R.S. Wells, and D. Mann. 2008. Depredation and fishing interactions involving bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. Southeast and Mid-Atlantic Marine Mammal Symposium, 28-30 March, Charleston, SC.
- Yordy, J., R. Wells, B. Balmer, L. Schwacke, T. Rowles and J. Kucklick. 2008. Distribution of organohalogen contaminants between blubber and blood in wild bottlenose dolphins: Implications for biomonitoring and health. Southeast and Mid-Atlantic Marine Mammal Symposium, 28-30 March, Charleston, SC. (Best PhD student presentation award)
- Balmer, B.C., R.S. Wells, S.M. Lane, L.H. Schwacke, T.R. Speakman, E.S. Zolman, W.A. McLellan, R.C. George and D.A. Pabst. 2008. A plan to monitor abundance, site-fidelity, and habitat utilization patterns of bottlenose dolphins (*Tursiops truncatus*) near a National Priority List (NPL) polluted site and an adjacent pristine reference site in Georgia. Southeast and Mid-Atlantic Marine Mammal Symposium, 28-30 March, Charleston, SC. (poster)
- Burdett, L.G., D.S. Rotstein, T.K. Rowles, L.H. Schwacke, F.I. Townsend, R.S. Wells and D.G. Hoel. 2008. A visual assessment tool to evaluate skin diseases in wild bottlenose dolphin (*Tursiops truncatus*) populations: A proposed methodology. Southeast and Mid-Atlantic Marine Mammal Symposium, 28-30 March, Charleston, SC. (poster)
- Kucklick, J., A. Guichard, J. Yordy, J. Litz, R. Wells, B. Balmer, A. Hohn, E. Zolman, L. Schwacke, T. Rowles, L. Hansen, C. Berry and P. Rosel. 2008. Concentrations and patterns of lipophilic pollutants in bottlenose dolphins (*Tursiops truncatus*) as a function of geographical scale and implications to dolphin health. Southeast and Mid-Atlantic Marine Mammal Symposium, 28-30 March, Charleston, SC. (poster)
- Wells, R.S., J.B. Allen, S. Hofmann, K. Bassos-Hull, D.A. Fauquier, N.B. Barros, R.E. DeLynn, G. Hurst, V. Socha and M.D. Scott. 2008. Re-capture history (fate) of bottlenose dolphins in Sarasota Bay post-injury. Joint Scientific Review Group Meeting, Monterey, CA, 8-9 January 2008.
- Camilleri, S., D. Gannon, E. Berens, J. Gannon, and M.K. Brueggen. 2008. Effects of red tide on the occurrence of fish calling. Poster presentation, annual meeting of the Florida Chapter of the American Fisheries Society. February 2008.
- Wells, R.S. and M.D. Scott. 2007. Long-term studies of bottlenose dolphins: an assessment of costs and benefits. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Wells, R.S. and J.B. Allen. 2007. Consequences of injuries on survival and reproduction of bottlenose dolphins in Sarasota Bay, Florida. NMFS Serious Injury Technical Workshop, 10-12 September 2007, Seattle, WA.
- Quintana-Rizzo, E. and R.S. Wells. 2007. The definition of a group in species with fluid relationships: the case of the bottlenose dolphin (*Tursiops truncatus*). 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Barros, N.B., J.G. Gannon and R.S. Wells. 2007. Combining long-term photo-identification and stranding data from west-central Florida, USA, resident bottlenose dolphins: a synergistic approach with implications for ecological studies. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.

- Fauquier, D., N. Barros, L. Flewelling, V. Socha, R. Pierce, J. Gannon, M. Kinsel, M. Stolen., J. Landsberg, and R.S. Wells. 2007. Brevetoxin induced mortality in stranded dolphins from central west Florida during 2005 and 2006. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- McHugh, K.A., S. Hofmann, J.B. Allen, M.D. Scott, and R.S. Wells. 2007. Factors influencing variation in age at independence for free-ranging bottlenose dolphin calves in Sarasota Bay, Florida. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Simard, P., R.S. Wells, J.B. Allen, M. Cook and D. Mann. 2007. Boat-based visual surveys and acoustic detection using manual methods and automatic recognition software: results from bottlenose dolphins (*Tursiops truncatus*) in Sarasota, Florida. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Sayigh, L.S., R.S. Wells and V.M. Janik. 2007. Signature whistle development in bottlenose dolphins. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Wells, R.S., S. Hofmann, J.B. Allen, K.W. Urian, K. Bassos-Hull, S.M. Nowacek, J.G. Gannon, N.B. Barros, D.A. Fauquier, M.D. Scott and R.C. Lacy. 2007. Impacts of human activities and natural events on the abundance and vital rates of bottlenose dolphins in Sarasota Bay, Florida. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Dunsha, G., S. Jarman, M. Hindell, R.S. Wells, D. Duffield and N. Gales. 2007. Telomeres of cetaceans and pinnipeds: initial experimental genomic characterization and examination of age related dynamics. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- West, K.L., R. Shah, O.T. Oftedal, R.S. Wells, D.P. Costa, and M.B. Kretzmann. 2007. Milk composition and calf growth in free-ranging bottlenose dolphins (*Tursiops truncatus*) from Sarasota Bay, Florida. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Gannon, J.G., J.B. Allen, D.P. Gannon, E.J. Berens, S. Hofmann, and R.S. Wells. 2007. Effects of harmful algal blooms on bottlenose dolphins (*Tursiops truncatus*): changes in distribution and behavior. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Gannon, D.P., A.S. Friedlaender, J.G. Gannon, E.J. Berens, J.B. Allen, S. Hofmann and R.S. Wells. 2007. Seeing the forest for the trees: comparing patterns of habitat selection at the level of the population and of the individual for bottlenose dolphins in Sarasota Bay, Florida. 17<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 29 November – 3 December, Cape Town, South Africa.
- Sayigh, L., H.C. Esch, J. Blum, and R. Wells. 2007. Whistles as potential indicators of stress in bottlenose dolphins. 21<sup>st</sup> Conference of the European Cetacean Society, San Sebastian, Spain, 23-25 April 2007. (poster)
- Quintana-Rizzo, E., D. Mann and R. Wells. 2007. Rango de comunicacion de los sonidos sociales de los delfines nariz de botella (*Tursiops truncatus*). Tercer Congreso de la Comisión Nacional de Ciencia y Tecnología, Convergencia. Julio 24-27, Ciudad de Guatemala, Guatemala.
- Yordy, J., R. Wells, A. Guichard, B. Balmer, L. Schwacke, T. Rowles and J. Kucklick. 2007. Shift of PBDE mixtures within a coastal bottlenose dolphin population in relation to life

- history and dietary exposure. 28<sup>th</sup> Annual Meeting of the Society of Environmental Toxicology and Chemistry. Milwaukee, WI, November 11-14.
- Kucklick, J.R., A. Guichard, J. Yordy, J. Litz, R. Wells, B. Balmer, A. Hohn, E. Zolman, L. Schwacke, T. Rowles, L. Hansen, C. Berrie and P. Rosel. 2007. Concentrations and patterns of lipophilic pollutants in bottlenose dolphins (*Tursiops truncatus*) as a function of geographical scale and implications to dolphin health. 27<sup>th</sup> International Symposium on Halogenated Persistent Organic Pollutants. Tokyo, Japan.
- Kucklick J.R., A. Guichard, J. Yordy, J. Litz, R. Wells, B. Balmer, A. Hohn, E. Zolman, L. Schwacke, T. Rowles, L. Hansen, C. Berrie and P. Rosel. 2007. Concentrations and patterns of lipophilic pollutants in bottlenose dolphins (*Tursiops truncatus*) as a function of geographical scale and implications to dolphin health. 28<sup>th</sup> Annual Meeting of the Society of Environmental Toxicology and Chemistry. Milwaukee, WI, November 11-14.
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- McHugh, K.A. and R.S. Wells. 2007. Red tide effects on juvenile bottlenose dolphin behavior in Sarasota Bay, FL. 44<sup>th</sup> Annual Meeting of the Animal Behavior Society, 21-26 July 2007, Burlington, VT.
- McHugh, K.A. and R.S. Wells. 2007. Red tide effects on juvenile bottlenose dolphin behavior in Sarasota Bay, FL. Southeast and Mid-Atlantic Marine Mammals Symposium, March 2007, Beaufort, NC.
- Wells, R.S., K. Bassos-Hull, J. Allen, N. Barros, D. Fauquier, J. Gannon and R. Lacy. 2006. Impacts of human activities on a long-term resident community of bottlenose dolphins on Florida's west coast. Defenders of Wildlife's Carnivores 2006. St. Petersburg, FL, 12-15 November 2006.
- Barros, N.B., P. Ostrom, C. Stricker and R. Wells. 2006. Bottlenose dolphin population differentiation and trophic studies using carbon, nitrogen, and sulfur stable isotopes and stomach content analyses. Defenders of Wildlife's Carnivores 2006. St. Petersburg, FL, 12-15 November 2006.
- Gannon, D.P., J. Allen, E. Berens, D. Fauquier, J. Gannon and R. Wells. 2006. Role of ecological disturbance in the foraging ecology of coastal bottlenose dolphins. Defenders of Wildlife's Carnivores 2006. St. Petersburg, FL, 12-15 November 2006.
- Carlson, S.L., V. Cornish, L. Engleby, K. Thoms, K. Wells, T. Spradlin and R. Wells. 2006. Feeding and harassment of wild bottlenose dolphins in the Southeastern Region: Overview of activities of concern and mitigation efforts. Defenders of Wildlife's Carnivores 2006. St. Petersburg, FL, 12-15 November 2006.
- Fire, S.E. 2006. Effects of red tide exposure on wild bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. SEAMAMMS 2006. March 2006. Ft. Lauderdale, FL.

- Fire, S.E. 2006. Effects of red tide exposure on wild bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. State of the Research on Red Tide in the Gulf of Mexico Workshop, Sarasota, FL, July 2006.
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- Yordy J., R. Wells, B. Balmer, L. Schwacke, T. Rowles, and J. Kucklick. 2006. Contaminant partitioning between blubber and blood in wild bottlenose dolphins: Implications for biomonitoring. SETAC, Montreal, Canada.
- Yordy, J., W.A. McLellan, D.A. Pabst, R. Wells, T. Rowles, and J. Kucklick. 2006. Tissue specific exposure to organohalogen contaminants in the bottlenose dolphin, *Tursiops truncatus*. SETAC, Montréal Canada.
- Quintana-Rizzo, E., D.A. Mann, and R.S. Wells. 2006. Estimacion del rango de comunicacion de los sonidos sociales usados por los delfines nariz de botella (*Tursiops truncatus*). X Congreso de la Sociedad Mesoamericana para par Biologia y la Conservacion. Antigua Guatemala Oct 29-Nov 3.
- Wells, R.S. and N.B. Barros. 2006. The combined application of photographic identification and genetic sampling to understanding population structure and dynamics of small cetaceans. Workshop on Research and Conservation of the Genus *Sotalia*, Armacao dos Búzios, Rio de Janeiro, Brazil, 19-23 June 2006.
- Wells, R.S. 2006. Follow-up monitoring as an integral component of cetacean rehabilitation programs. Keynote Address. Southeast Region Marine Mammal Stranding Network Biennial Conference. May 3-5, 20006. Panama City, FL.
- Berens, E. and D.P. Gannon. 2006. Effects of red tide on the availability of prey for bottlenose dolphins. Oral presentation, Southeast and Mid-Atlantic Marine Mammal Symposium, Nova Southeastern University, Ft. Lauderdale, FL.
- Allen, J.B., S. Hofmann, J.G. Gannon, and R.S. Wells. 2005. Behavior of orphaned bottlenose dolphin calves within a long-term resident community in Sarasota Bay, Florida. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Balmer, B.C., R.S. Wells, S.M. Nowacek, W.A. McLellan, T.K. Rowles, and D.A. Pabst. 2005. Short-term ranging patterns of bottlenose dolphins (*Tursiops truncatus*) in and around St. Joseph Bay, Florida, USA. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Barbieri, M.M., W.A. McLellan, R.S. Wells, J.E. Blum, S. Hofmann, and D.A. Pabst. 2005. Physiological and behavioral mechanisms of thermoregulation in bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida, U.S.A. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Bassos-Hull, K., C.A. Shepard, S. Schilling, J.B. Allen, J.G. Gannon, and R.S. Wells. 2005. Bottlenose dolphin abundance, distribution, seasonal and long-term site fidelity in the Charlotte Harbor ecosystem on the West Coast of Florida. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Brueggen, M.K., D.P. Gannon, and R.S. Wells. 2005. Effects of bottlenose dolphin sounds on the acoustic behavior of spotted sea trout. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Bryan, C.E , S.J. Christopher, W.C. Davis, R.D. Day, A.A. Hohn, and R.S. Wells. 2005. Establishing baseline trace element concentrations for bottlenose dolphins in Sarasota Bay,

- Florida through non-lethal monitoring of tissues and further exploring mercury levels in relation to life history data. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Cook, M.L.H., R.S. Wells, and D.A. Mann. 2005. Auditory evoked potential (AEP) hearing measurements in free-ranging bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Esch, H.C., L.S. Sayigh, and R.S. Wells. 2005. Whistles as potential indicators of stress in bottlenose dolphins. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Fauquier, D., M. Kinsel, M. Dailey, G. Hurst, N. Barros, M. Stolen, S. Rommel, R.S. Wells, and F. Gulland. 2005. Assessing the impact of lungworm infection on the health of wild bottlenose dolphins in central west Florida. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Gannon, D., E. Berens, and R.S. Wells. 2005. Fisheries science for marine mammalogists: Factors to consider when selecting a method for sampling fish populations. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Gannon, J.G., D.P. Gannon, E. Berens, and R.S. Wells. 2005. Using data on *Tursiops truncatus* ecology to evaluate two methods for assessing differences in distribution: Syrjala's procedure and Williamson's index of spatial overlap. Poster presentation, GIS Workshop of the Sixteenth Biennial Meeting of the Society for Marine Mammalogy, San Diego, CA.
- Houde, M., B.C. Balmer, T.A.D. Bujas, R.S. Wells, A.A. Hohn, J.C. Sweeney, G.D. Bossart, P.A. Fair, K.R. Solomon, and D.C.G. Muir. 2005. Emerging perfluorinated contaminants in bottlenose dolphins (*Tursiops truncatus*) from the Atlantic Ocean and the Gulf of Mexico. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Gannon, J.G., R.S. Wells, and S. Hofmann. 2005. Fine-scale natal philopatry and sex differences of bottlenose dolphins in Sarasota Bay, Florida. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Janik, V.M., L.S. Sayigh, and R.S. Wells. 2005. Signature whistle shape conveys identity information to bottlenose dolphins. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Klatsky, L., R.S. Wells, and J. Sweeney. 2005. Bermuda's deep diving dolphins - Movements and dive behavior of offshore bottlenose dolphins in the northwest Atlantic Ocean near Bermuda. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Kucklick, J., J. Yordy, A. Peck, R.S. Wells, A. Hohn, J. Litz, L. Schwacke, B. Balmer, L. Hansen, E. Zolman, and T. Rowles. 2005. Spatial and temporal trends of brominated flame retardants in dolphins from the western North Atlantic Ocean and eastern Gulf of Mexico. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.
- Pabst, D.A., W.A. McLellan, S.A. Rommel, M.D. Scott, A.B. Irvine, J.C. Sweeney, R. Stone, A.S. Friedlaender, E.M. Meagher, A.A. Hohn, and R.S. Wells. 2005. Ontogeny of temperature regulation of the testes of male bottlenose dolphins (*Tursiops truncatus*): insights from long-term field studies. 16<sup>th</sup> Biennial Conference on the Biology of Marine Mammals. December 12-16, 2005, San Diego, CA.

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- Wells, R.S. and S. Nowacek. 2001. Human interactions with Florida's marine mammals. Viewing Marine Mammals in the Wild: A Workshop to Discuss Responsible Guidelines and Regulations for Minimizing Disturbance. 14<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 28 Nov-3 Dec, Vancouver, BC (Oral Presentation).
- Wells, R.S., D. Duffield, and A.A. Hohn. 2001. Reproductive success of free-ranging bottlenose dolphins: Experience and size make a difference. 14<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 28 Nov-3 Dec, Vancouver, BC (Oral Presentation).
- Westgate, A., D.A. Pabst, W.A. McLellan, E.M. Meagher, R.S. Wells, M.D. Scott, T.A. Williams, S.A. Rommel, and T.K. Rowles. 2001. Some like it hot: Measuring heat flux and temperature from wild bottlenose dolphins. 14<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 28 Nov-3 Dec, Vancouver, BC (Oral Presentation).
- Wells, R.S., T.K. Rowles, and H.L. Rhinehart. 2001. Pollution 2000+: Bottlenose dolphin sampling progress during 2000-2001. 53<sup>rd</sup> Meeting of the Scientific Committee of the International Whaling Commission, July 6-12, Hammersmith, U.K.
- Wells, R.S. 2001. Evaluating health risks in free-ranging bottlenose dolphin populations. Invited Plenary Presentation, 32<sup>nd</sup> Annual Conference of the International Association for Aquatic Animal Medicine, April 28 – May 2, 2001, Tampa, FL.

## **6b. Educational Programs**

Since the initiation of the program in summer 2001, 25 graduate students have conducted field work or data analyses on bottlenose dolphins in association with our program (12 MS, 13 PhD). During this same period we have had 155 undergraduate interns working with the program, along with teams of up to 5 Earthwatch Institute volunteers monthly through August 2007, and a number of international colleagues.

We have worked with educational staff from Brookfield Zoo and Mote Marine Laboratory to develop informal education programs as well as web-based curriculum and distance learning programs on bottlenose dolphins as part of a companion Department of Education grant. One result of this effort is the innovative "Secret Life of Dolphins" inquiry-based curriculum for high school students that makes direct use of our databases and approaches to questions about dolphin biology and conservation. Teacher workshops were initiated during 2004 to train them for presenting this curriculum, and it is being implemented in classrooms in Florida and Illinois. We are currently working to make this full curriculum available at no cost on websites for the Chicago Zoological Society, Mote Marine Laboratory, Sarasota Dolphin Research Program, and the Society for Marine Mammalogy.

We developed a program to visit the 5<sup>th</sup> grade classes of Sarasota County and made presentations on dolphin and manatee biology, conservation issues, and how to treat the animals in the wild. In addition, the Chicago Zoological Society's Brookfield Zoo developed an exhibit that is a simulated dolphin survey through Sarasota Bay, presenting findings resulting from this initiative. Mote Marine Laboratory developed an Immersion Cinema program, "The Dolphin Bay Project", which is a novel interactive cinema approach to presenting our scientific and rescue tools, approaches, findings, and conservation concerns to the public.

The following lectures were presented by Wells and colleagues at colleges, universities, schools, or other public organizations since the inception of the project.

### College/University/Public Lectures

- Wells, R.S. 2008. Factors influencing the health and survivorship of bottlenose dolphins in Florida. SEAVET, Sarasota, FL. 24 Jun 2008.
- Wells, R.S. 2008. "Learning from nature: CZS bottlenose dolphin care and husbandry." Nights in the Wild, Brookfield Zoo, Brookfield, IL. 20Jun08
- Wells, R.S. 2008. Factors influencing the health and survivorship of bottlenose dolphins in Florida. MARVET, Sarasota, FL. 3 Jun 2008.
- Wells, R.S. 2008. Will the wonders never cease? Keynote address, Florida Marine Science Educators' Association Annual Meeting, Museum of Science and Industry, Tampa, FL. 26 Apr 2008.
- Wells, R.S. 2008. Wild dolphin societies: Lessons from 37<sup>+</sup> years and 5 generations. The Propeller Club. Mote Marine Laboratory. 11 Apr 08.
- Wells, R.S. 2008. Wild dolphin societies: Lessons from 37<sup>+</sup> years and 5 generations. Mote Marine Laboratory Volunteer Class. 26 Mar 08.
- Wells, R.S. 2008. Five generations of wild dolphins in Sarasota Bay: Their biology and how humans impact them. Books with Bites, Mote Marine Laboratory. 16 Feb 2008.
- Wells, R.S. 2008. The bottlenose dolphins of Sarasota Bay: lessons from 37 years and 5 generations. Keynote Address: Friends of Chassahowitzka Annual Meeting. Crystal River, FL. 27 Jan 2008.
- Wells, R.S. 2007. Secret lives of dolphins. Bedford Court Retirement Community, Silver Spring, MD. 8 Dec 2007.
- Wells, R.S. 2007. The bottlenose dolphins of Sarasota Bay: lessons from 37 years and 5 generations. Sigma Xi Lecture, Eckerd College, St. Petersburg, FL. 13 Nov 2007.
- Wells, R.S. 2007. Cetaceans of the Gulf of Mexico: Biology and research. Training class for Cuban and Mexican scientists and students, Isla Mujeres, Mexico, 14 Sep 2007.
- Wells, R.S. 2007. University of Chicago Field Ecology Course, Sarasota Bay, 24 Mar 2007.
- Wells, R.S. 2007. Wild dolphin societies: a tale of two cetaceans. Whale Quest, Kapalua, Maui, Hawaii. 17 Feb 2007.
- Wells, R.S. 2007. The bottlenose dolphin community of Sarasota Bay: Lessons from 37 years and 5 generations. Siesta Key Chapel. 16 Jan 2007.
- Gannon, D.P. 2007. Effects of *Karenia brevis* harmful algal blooms on an estuarine fish community. Invited lecture, Bowdoin College, Brunswick, ME. Dec. 2007.
- Gannon, D.P. 2007. Effects of *Karenia brevis* harmful algal blooms on an estuarine fish community. Invited lecture, Eckerd College, St. Petersburg, FL. Nov. 2007.
- Gannon, D.P. 2007. Noisy fishes, silent dolphins, and the toxic tide that plagues them. Fall seminar series, Mote Marine Laboratory, Sarasota, FL. Nov. 2007.
- Gannon, D.P. 2007. Ecological effects of *Karenia brevis* harmful algal blooms on estuarine communities. Invited lecture, Florida State University. Mar. 2007.
- Gannon, D.P. 2006. Silent dolphins, noisy fishes, and the toxic tide that plagues them. Invited Lecture, California State University, Northridge.
- Wells, R.S. 2006. Factors influencing the health and survivorship of bottlenose dolphins in Florida. Introduction to Conservation Medicine and Ecosystem Health. Conservation Medicine Center of Chicago, Loyola University/University of Illinois College of Veterinary Medicine. 10 Oct 2006.
- Wells, R.S. 2006. Mote's Center for Marine Mammal and Sea Turtle Research. Peace River Power Squadron, Port Charlotte, FL. 26 Sep 2006.

- Wells, R.S. 2006. Bottlenose dolphin social structure and effects of red tide. Zoo University, Brookfield, IL. 29 Mar 2006.
- Wells, R. S. 2006. Meeting the challenges of the life aquatic. Brookfield Zoo Spring Lecture Series, Brookfield, IL. 28 Mar 2006.
- Wells, R. S. 2006. The bottlenose dolphin community of Sarasota Bay: Lessons from 36 years and 5 generations. Biology Dept. Seminar, University of South Florida, Tampa, FL. 23 Mar 2006.
- Wells, R. S. 2006. Dolphins in the Wild. Mote Family Programs, Mote Marine Laboratory, Sarasota, FL. 11 Feb 2006.
- Wells, R. S. 2006. Mote's Center for Marine Mammal and Sea Turtle Research. Boater's Lunch, Bird Key Yacht Club, Sarasota, FL. 8 Feb 2006.
- Wells, R. S. 2006. Wild dolphin societies: Lessons from 36 years and 5 generations. Sunnyside Academy, Sarasota, FL. 7 Feb 2006.
- Wells, R. S. 2006. Extending the reach of Brookfield Zoo's flippers for dolphin conservation. Brookfield Zoo Women's Board Meeting, Chicago, IL. 18 Jan 2006.
- Wells, R. S. 2005. Wild dolphin societies: Lessons from 36 years and 5 generations. Purdue University Alumni Club, Sarasota, FL. 29 Nov 2005
- Wells, R. S. 2005. Making a career of studying Sarasota Bay's bottlenose dolphins. Career Ladder Keynote Address, Brookfield Zoo. 19 Nov 2005
- Wells, R. S. 2005. Dolphin family values. SunCoast Reef Rovers Dive Club, Nokomis, FL. 21 Sep 2005
- Wells, R. S. 2005. Wild dolphin societies: Lessons from 35 years and 4 generations. Northwestern University Alumni Club, Sarasota, FL. 19 May 2005
- Wells, R. S. 2005. Dolphin family values. Longbeach Village Association, Sarasota, FL. 2 Feb 2005
- Wells, R. S. 2005. Dolphin Immersion at Mote: 35 years in the making. Monday at Mote, Sarasota, FL. 24 Jan 2005
- Wells, R. S. 2005. Dolphin family values: Bottlenose dolphin conservation based on long-term behavior, ecology, life history and health research. Evening Tide Talks, The Florida Aquarium, Tampa, FL. 20 Jan 2005
- Wells, R. S. 2004. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. Biology of Marine Mammals, University of Miami. 30 Oct 2004
- Wells, R. S. 2004. The secret lives of Sarasota Bay's bottlenose dolphins. MaST Research Institute, Sarasota High School, Sarasota, FL. 29 Oct 2004
- Wells, R. S. 2004. Dolphin family values. Lowell Lecture Series, New England Aquarium, Boston, MA. 25 Oct 2004
- Wells, R. S. 2004. Conservation Matters, Brookfield Zoo, Brookfield, IL. 1 Oct 2004
- Wells, R. S. 2004. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. SEAVET course, University of Florida. 2 Aug 2004
- Wells, R. S. 2004. Caring for and caring about bottlenose dolphins – perspectives from 34 years of collaborative dolphin research. Invited Presentation, Marine Mammal Alliance Educator's Annual Meeting, Orlando, FL. 16 Jul 2004
- Wells, R. S. 2004. Integrating life history, health, and reproductive success data to examine potential relationships with organochlorine contaminants for bottlenose dolphins in Sarasota

- Bay, Florida. Marine Mammal Toxicology, Woods Hole Oceanographic Institution. 1 Apr 2004
- Wells, R. S. 2004. Dolphins, manatees, and sea turtles from Osprey to Boca Grande: Current Mote Marine Laboratory research and conservation activities, and plans for the future. Gulf Coast Community Foundation of Venice, Venice, FL. 17 Feb 2004
- Wells, R. S. 2004. Dolphin family values. Sarasota Boat Club, Sarasota, FL. 12 Feb 2004
- Wells, R. S. 2004. CZS Sarasota Dolphin Research Program: Helping to make CZS a place where conservation, research, education, and animal programs intersect seamlessly. Board of Trustees Retreat, Chicago Zoological Society, Brookfield, IL. 7 Feb 2004
- Wells, R. S. 2004. History and overview of Mote Marine Lab's Marine Mammal Stranding Response Program. MML Animal Care Class, Sarasota, FL. 24 Jan 2004
- Wells, R. S. 2004. Discovering dolphins and manatees in our backyards. Brentwood Elementary School (two 5<sup>th</sup> grade classes), Sarasota, FL. 14 Jan 2004
- Wells, R. S. 2004. Discovering dolphins and manatees in our backyards. Philippi Shores Elementary School (5<sup>th</sup> grade class), Sarasota, FL. 13 Jan 2004
- Wells, R. S. 2004. Discovering dolphins and manatees in our backyards. Venice Elementary School (two 5<sup>th</sup> grade classes), Venice, FL. 13 Jan 2004
- Wells, R. S. 2003. Bottlenose dolphins and human interactions. NMFS Headquarters, Silver Spring, MD. 15 Jul 2003
- Wells, R. S. 2003. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. Biology of Marine Mammals course, University of California, Santa Cruz, CA. 8 May 2003
- Wells, R. S. 2003. The lives of Sarasota Bay's bottlenose dolphins. College of Veterinary Medicine, University of Florida, Gainesville, FL 9 Jan 2003
- Wells, R. S. 2003. Dolphin family values. Monday Night at Mote, Mote Marine Laboratory, Sarasota, FL. 13 Jan 2003
- Wells, R. S. 2003. Bottlenose dolphin conservation and long-term research along Florida's west coast. College of Veterinary Medicine, University of Florida, Gainesville, FL. 9 Jan 2003
- Wells, R. S. 2003. The lives of Sarasota Bay's bottlenose dolphins. College of Veterinary Medicine, University of Florida, Gainesville, FL 9 Jan 2003
- Wells, R. S. 2002. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. Biology Dept., University of North Carolina, Wilmington. 12 Sep 2002
- Wells, R. S. 2002. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. Sanibel-Captiva Conservation Foundation, Sanibel, FL. 16 Jul 2002
- Wells, R. S. 2002. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. Biology of Marine Mammals course, University of California, Santa Cruz, CA. 14 May 2002
- Wells, R. S. 2002. Bottlenose dolphins and human interactions. NMFS Southeast Regional Office, St. Petersburg, FL. 19 Apr 2002
- Wells, R. S. 2002. Conservation Matters, Brookfield Zoo, Brookfield, IL. 13 Apr 2002
- Wells, R. S. 2002. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. University of South Florida, St. Petersburg, FL. 25 Jan 2002
- Wells, R. S. 2001. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. University of Michigan, Ann Arbor, MI. 26 Oct 2001

Wells, R. S. 2001. Bottlenose dolphin conservation based on long-term behavior, ecology, life history, and health research. University of Miami. 22 Oct 2001

Wells, R. S. 2001. Odontocete life history. Biology of Marine Mammals course, Eckerd College, St. Petersburg, FL. 15 Oct 2001

### **6c. Data Analysis (Statistical Consultations, GIS, Modeling)**

**Project Synopsis:** The projects supported by this award have produced large quantities of data since the program's inception in 2001. In order to make the most of the data produced by this research, we plan to engage the services of a highly experienced biometrician, in addition to the Geographical Information System specialist hired with the last round of funding. These two positions will provide crucial support to the scientists engaged in the other projects supported by this award, and their assistance will expedite production and publication of statistically-robust scientific manuscripts. In addition, these positions will help incoming graduate students with developing solid research designs.

**Participants:** Janet Gannon, SDRP, Lori Schwacke

**Accomplishments:** This award allowed us to engage the services of biometrician Dr. Lori Schwacke and GIS and Access database expert Janet Gannon. They provided much-needed guidance to staff and students, and contributed greatly to the productivity of the program. Gannon made tremendous progress in developing our sighting database. The Sarasota Dolphin Research Project database continues to grow. There are presently more than 35,000 encounters with dolphin groups in the database since 1970, and more than 100,000 identifications of marked individuals resulted from those encounters. The database as a whole includes about 3,500 distinct individuals plus some of their calves, ranging from the Tampa area to the Charlotte Harbor area. The database continues to be a source of high-quality data for a range of projects.

**Need for Additional Work:** Although much more analytical work could be done with the databases created or enhanced through this project, the program no longer has the dedicated services of Dr. Schwacke or Janet Gannon. Dr. Schwacke returned to her position with NOS, but she continues to provide consultations and participate in collaborations with our program. With the end of project support for Damon and Janet Gannon, they have taken new positions in Maine.

## **Evaluation**

Overall, the project was very successful. Each of the Jobs has been described and evaluated individually above. Twenty-nine of the 33 Jobs were completed as proposed, meeting the goals and objectives in full or to the extent possible. Jobs 4b. and 4d., dealing with the impacts of boats and noise on dolphin habitat use, were to have formed the basis of a dissertation project. However, the student left the program before the project could be completed, and no other student was found to replace her. Job 1e.3. investigating factors associated with juvenile survival, was briefly delayed after the Master's student planning to conduct the work failed to enter the program, but the project was soon taken up and is being successfully completed by a doctoral student. The contaminant sampling portion of Job 2a.2. was completed through biopsy dart sampling, but health assessment capture-release efforts in Charlotte Harbor were considered to be too risky, and this component was dropped, in consultation with our NMFS Grants Officer.

Funds were reprogrammed for additional environmental contaminant analyses. While Job 1f. did not lead to the proposed comparative analyses and workshop, it did lead to the successful development of an objective and rigorous definition of a population unit for Sarasota Bay and selection of an appropriate dataset for which abundance and vital rate values are currently being developed. The approach to defining the population unit has been reviewed and is supported by several pre-eminent scientists in this analytical area. The data are now being prepared for publication in peer-reviewed scientific journals, and they have been recently applied to current international conservation issues.

The project greatly enhanced the capacity of the Chicago Zoological Society's Sarasota Dolphin Research Program to perform bottlenose dolphin research of value and relevance to the mandate of the National Marine Fisheries Service for providing protection to this species. The publication and presentation record documents the high level productivity of the project, as does the large number of graduate and undergraduate students who participated over the seven years of the project, whose efforts, training, and expertise contributed greatly to the program and should continue to benefit marine mammal conservation for many years to come.