ANNUAL PROGRESS REPORT

Grant #: N00014-92-J-1971 R&T Code: 4414217

PRINCIPAL INVESTIGATOR: Dr. Bruce R. Mate

INSTITUTION: Oregon State University

GRANT TITLE: Satellite-Acquired Whale Movements and Acoustic Monitoring

REPORTING PERIOD: 1 June 1993 - 31 May 1994 (12 months, year 2)

AWARD PERIOD: 1 June 1992 - 31 May 1995

OBJECTIVE: To track whales via satellite-monitored radio tags, improve attachment longevity, and incorporate a low-frequency sound sensor which detects vocalizations.

APPROACH: In collaboration with C. Clark (Cornell), an acoustic sensor is being developed to monitor selected low-frequency sound (LFS) including blue whale vocalizations. The sensor is being incorporated into an Argos (satellite-monitored) radio transmitter with specialized event-driven software to determine when and at what depth blue whales vocalize. A miniaturized location-only (MLO) Argos tag has been developed to determine if reduced hydrodynamic drag of the smaller tag will result in longer tag attachment (tracking).

ACCOMPLISHMENTS:

1. Mate, Mesecar and Martin (OSU) met at Cornell with Clark, Shamoon, Mitchell, Calupca, Mellinger and Corzillius and developed a data collection and summary strategy based on the desirable acoustic data and Argos baud rate limitations. The resulting LFS sensor and software are nearly complete. The LFS tag will report durations and maximum depths of sequential dives with duration and depth of LFS above a specific threshold. Whale vocalizations will be determined by duration data.
2. In September, we tagged 10 blue whales off California. Dive depths and durations were received for up to 13 days. The whales moved at 15km/hr between krill patches so drag was a big problem. Blue whale vocalizations were recorded using the new LFS sensor in a tethered configuration. Kate Stafford (OSU MS student) used these recordings to model blue whale calls ("kernel") and create a matched filter. The filter finds blue whale calls in noisy IUSS data. She and Dr. Chris Fox (PMEL) are examining Pacific IUSS records to evaluate the seasonal and geographic distribution of blue whale calls to describe annual movements. Our IUSS data show some blue whales off Oregon through November.
3. The miniaturized location-only (MLO) tag has been tested to 3,000 m depths and is 70% smaller than our previous tags. MLO tags were placed on a blue whale, 4 sperm whales and 2 bottlenose dolphins this year. Implantation attempts were unsuccessful on 2 sperm whales and a blue whale. A surface attachment similar to the way we attach larger tags was used successfully on 3 sperm whales in the Galapagos with multiple resightings. Islands. Unfortunately, we received no data from the 3 MLO tags or 2 sensor tags. The latter have

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1995 1027 083

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1. Reference: DoD Directive 5230.24, Distribution Statements on Technical Documents, 18 Mar 87.

2. The Defense Technical Information Center received the enclosed report (referenced below) which is not marked in accordance with the above reference.

ANNUAL PROGRESS REPORT
N00014-92-J-1971
TITLE: SATELLITE-ACQUIRED WHALE MOVEMENTS AND ACOUSTIC MONITORING

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A

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DEPUTY DIRECTOR
CORPORATE PROGRAMS OFFICE

(Signature & Typed Name)

(Assigning Office)

25 SEP 1995

(Date Statement Assigned)

been used successfully on 3 other species. We believe the very loud vocalizations of sperm whales may be fracturing the timing crystals and have found a facility to test this theory.

4. Two MLO tags were successfully deployed on bottlenose dolphins off the south Texas coast. Both tags are still active as of this report for 47 and 22 days. By limiting transmission to specific orbit times, MLO tags may last 14 months. Two pilot whales tagged in Florida in 1991 were re-sighted in Feb. 1994, 31 months later, suggesting long term attachment and tracking are indeed feasible.

5. During our sperm whale studies in the Gulf of Mexico, we found an unusual distribution of exclusively immature animals in water 700 to 1,200m deep. This segregation has not been reported elsewhere. Stranding records show large animals do inhabit the Gulf. As we surveyed further to find large animals, we documented this distribution over several weeks and found the animals left the area completely when a seismic survey began.

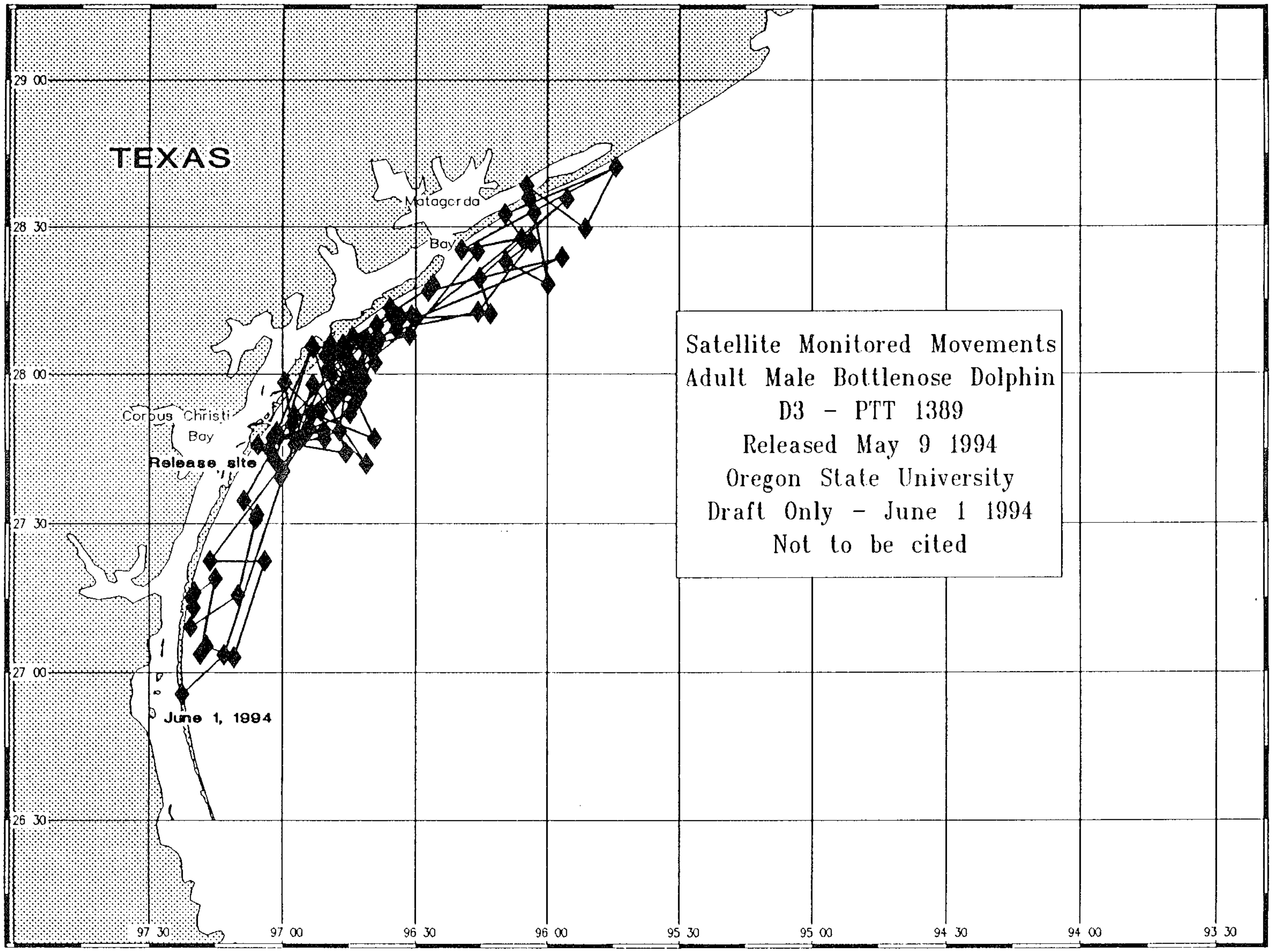
SIGNIFICANCE: 1) The acoustic sensor tag will tell us how often and at what depth blue whales vocalize, which will help interpret IUSS data. 2) The matched filter will help automate detection of blue whale calls in IUSS data. 3) We have found a statistically significant change in the distribution of sperm whales in relation to seismic survey activity. 4) The identification of tag parts sensitive to loud noise is important to future LFS monitoring success. 5) The 31 month attachment of a dorsal fin saddle on 2 pilot whales is the longest record of an external attachment to a cetacean and suggests an effective system which warrants the development of long life tags. 6) The bottlenose dolphin tags presently in the Gulf are designed to last one year. One of those tags has already exceeded the longest track and attachment record for that species by moving 2,336km to offshore Louisiana. 7) ONR-supported native American received a B.S. in Computer Science and was subsequently hired. Two female graduate students working toward M.S. degrees received support.

WORK PLAN (Next 12 months): We will finish the acoustic sensor integration into the Argos tag and deploy (with ATOC co-funding) 10 of them on blue whales off California. We will analyze the resulting data to determine where, when and how deep blue whales vocalize. The seasonal and geographic distribution of blue whale calls in the Pacific will be documented with IUSS for an entire year. We will follow up our investigation into tag failure on sperm whales with additional high intensity sound testing. The tagged dolphins will be monitored and the managerial implications evaluated with respect to stock identity and water mass contacts (for recent strandings implications). Additional rehabilitated animals will be tagged if the opportunity arises. Surface attached MLO tags will be deployed on a variety of species to evaluate the relationship between hydrodynamic drag and attachment life. With co-funding, we expect to tag gray, bow, right and humpback whales.

PUBLICATIONS, ABSTRACTS AND INVITED LECTURES/WORKSHOPS

Mate,B.R., K.M. Stafford, R. Nawojchik and J.L. Dunn, 1994. Movements and dive behavior of a satellite-monitored white-sided dolphin in the Gulf of Maine. Mar. Mamm. Sci. 10(1):116-121.

Two IWC working papers; Abstracts: Soc. for Mar. Mamm. (X2); J.Acoust. Soc. Am.; Min. Mgmt. Ser. Info. Trans. Mtg (X2); Mex. Soc. for Mar. Mamm.; lecture: Charles Darwin Res. Lab, Galapagos; wksps: MMC (permits & take); IUSS (Woods Hole).


Satellite Monitored Movements
Adult Male Bottlenose Dolphin
D3 - PTT 1389
Released May 9 1994
Oregon State University
Draft Only - June 1 1994
Not to be cited
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Matagorda
Bay
Corpus Christi
Bay
Release site
June 1, 1994
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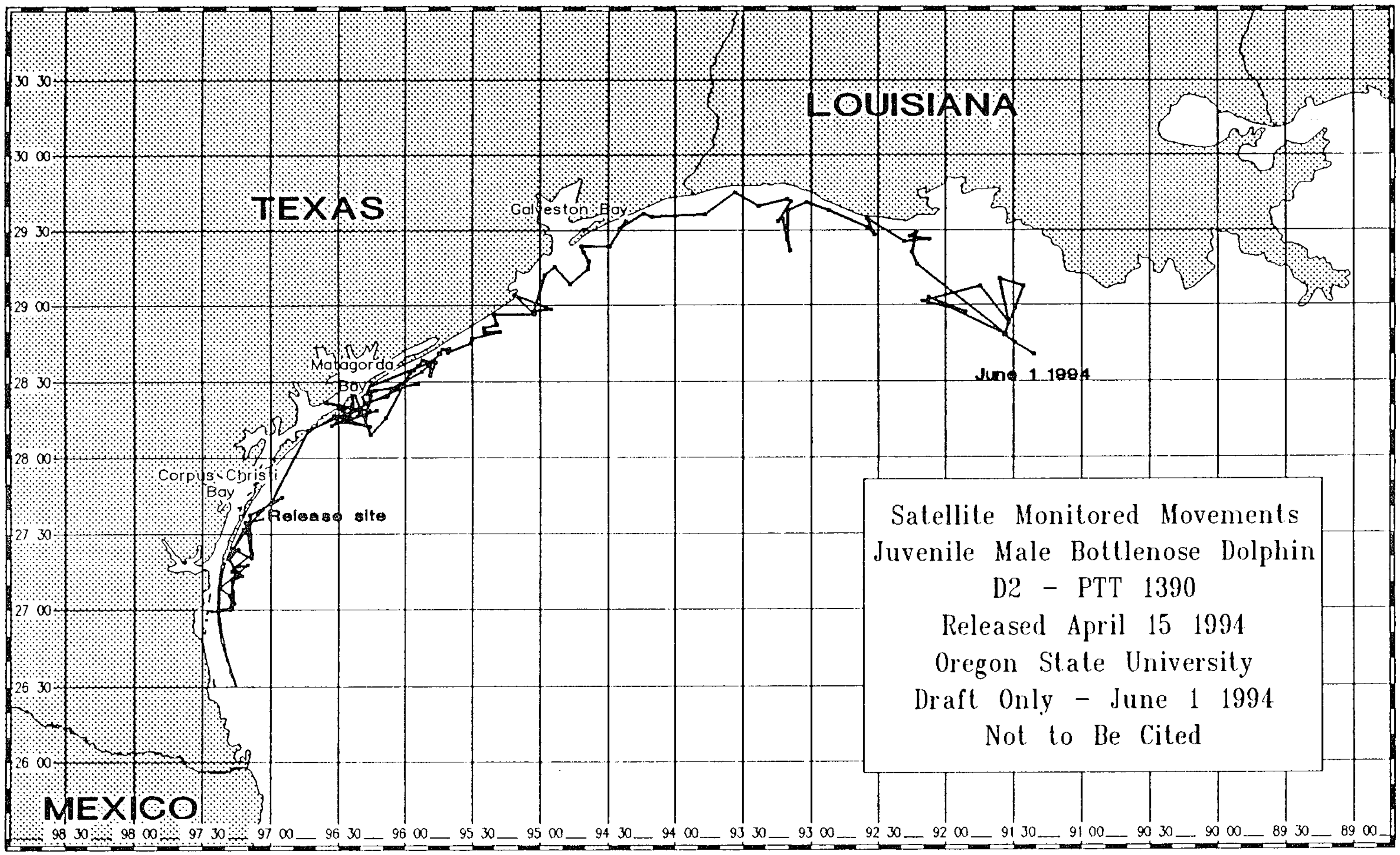
Satellite Monitored Movements
Juvenile Male Bottlenose Dolphin
D2 - PTT 1390
Released April 15 1994
Oregon State University
Draft Only - June 1 1994
Not to Be Cited
LOUISIANA
TEXAS
MEXICO
Galveston Bay
Matagorda Bay
Corpus Christi Bay
Release site
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ANNUAL REPORT QUESTIONNAIRE
(for ONR use only)

Principal Investigator: BRUCE R. MATE
Institution: OREGON STATE UNIVERSITY
Project Title: Satellite-Acquired Whale Movements and Acoustic Monitoring

Number of **ONR** supported

Papers published in refereed journals: 1
Papers or reports in non-refereed publications: 3
Books or book chapters published: 0

Number of **ONR** supported patents/inventions
Filed: 0
Granted: 0
Patent name(s) and number(s): 0

HAVE YOU LICENSED TECHNOLOGIES (E.G., SOFTWARE) THAT WERE DEVELOPED WITH ONR SUPPORT? IF SO, PLEASE DESCRIBE ON A SEPARATE SHEET. No.

HAVE YOU DEVELOPED INDUSTRIAL/CORPORATE CONNECTIONS BASED ON YOUR ONR SUPPORTED RESEARCH? IF SO, PLEASE DESCRIBE ON A SEPARATE SHEET. Yes. We have provided Wildlife Computers with software solutions to orbitography and error detection.

Number of presentations:	Total	ONR Project
Invited:	5	3
Contributed:	2	1

Trainee Data (only for those receiving full or partial **ONR** support):

	TOTAL	FEMALE	MINORITY	NON-US CITIZEN
No. Grad. Students:	2	2		
No. Postdoctorals:	0			
No. Undergraduates:	1		1	

AWARDS/HONORS TO PI AND/OR TO MEMBERS OF PI'S RESEARCH GROUP (please describe):

Equipment purchased on grant (number and description of items costing >$1,500):

10 tags at $5,000 each.

Satellite Acquired Whale Movements and Acoustic Monitoring
B. Mate, Oregon State University

OBJECTIVES

- Improve tag performance
  •size •software •attachment
- Develop LFS acoustic sensor for Argos tag
  • obtain blue whale vocalization data
- Tag whales/data acquisition
  •longevity •dive data •vocalizations

ACCOMPLISHMENTS

- Dorsal fin saddle resighted 31 months after tagging on 2 pilot whales
- Pacific blue whale vocalizations recorded
- Match filter developed - IUSS detection improved
- Build/test LFS sensor and software (with Cornell)
- Miniaturized location-only tag tested to 3,000 m; 70% smaller; 14 month life; applied to:
  4 sperm whales 1 blue whale
  2 dolphins - 48 days/2,336 km/144 locations
  - 23 days/2,215 km/113 locations
- Sensor tags on 10 blue whales: average dive duration (>1min)=5.9min.
  % time at depth: 75% @ 0-16 m; <1% @ 150-200 m
- Seismic survey appears to significantly affect sperm whale distribution

SIGNIFICANCE

- Long term attachment proved feasible on small cetaceans
- One year tag life achieved in small size location-only tag with differential sampling
- Match filter detects blue whale vocalizations out of IUSS background "noise"
- LFS sensor will determine when blue whale vocalize and at what depth
- Tagged dolphins show long distance nearshore movement and movement offshore - species record for duration & distance
- Student training: 1 Native American B.S. and 2 female M.S. candidates

Soc. Mar. Mammalogy 1993.

MOVEMENTS AND DIVE HABITS OF BOWHEAD WHALES FROM SATELLITE-MONITORED RADIO TAGS

Bruce R. Mate and Greg Krutzikowsky
Oregon State University, Hatfield Marine Science Center, Newport, OR 97365

Twelve bowhead whales (*Balaena mysticetus*) were radio tagged in late summer 1992 in the Canadian Beaufort Sea near the Mackenzie River delta. The tags were located and monitored by satellite. The tags transmitted data on dive durations, depths and temperatures.

Tags were heard up to 50 days after tagging. At least six of the tags likely stopped transmitting because of low battery voltage. One whale was located 278 times during 34 days as it moved from Canada to Siberia. Extended activity around Demarcation Bay reinforces the notion that this area may be important for feeding. Satellite images show a close association with the pack ice edge during migration through the Chukchi Sea. Temperature data also reinforce the bowhead's image as a pagophilic (ice-loving) species. Some dives exceeded 25 minutes, affirming the species' reputation for longer dives than other baleen whales. Dives of at least 344 m were recorded. This study is the first documentation of bowhead migration across the Chukchi and the amount of time spent at various depths.

For SMM Conf. Nov. 1993/Texas

HABITAT ÜBER ALLES!

Mate, Bruce R.
Oregon State University, Hatfield Marine Science Center, Newport, OR 97365

The future of whales depends upon the continued availability and suitability of their critical habitats. However, for many species these reasonably important areas remain largely unknown. Often little is also known about why the areas they inhabit are preferred. Recent detailed studies on a few species suggest some feasibly high site fidelity for benthic feeding gray whales versus wide-ranging searches in these dimensions by others. In "normal" years, most species show preferences for areas where their prey are usually found in high concentrations. The regular use of banks, basins, escarpment edges, ice edges and offshore canyons for feeding can often be attributed to increased productivity or prey concentration from areas of upwelling, eddies, convergence zones and river plumes.

For some of the same reasons, these areas are also used to harvest fish resources by man. Whale habitats for feeding, breeding and calving are commonly nearshore and, thus, exposed to nets, commercial shipping, mineral exploration/production and recreational boating/tourism. Without appropriate attention to these potentially competitive uses, the future of whales will be lost not because of commercial hunting, but the loss of critical habitat due to ignorance and benign neglect. We must strengthen our efforts worldwide to understand why certain areas are so important to whales and how man's activities can co-exist without adverse impact.

Session 4aAB

Animal Bioacoustics, Acoustical Oceanography, and Underwater Acoustics: Effects of Noise on Marine Mammals I

W. John Richardson, Chair
LGL Limited, 22 Fisher Street, P.O. Box 280, King City, Ontario L0G 1K0, Canada

Chair's Introduction—8:25

Invited Papers

8:30

4aAB1. Behavioral and hearing responses of pinnipeds to rocket launch noise and sonic boom. Brent S. Stewart (Hubbs–Sea World Res. Inst., 1700 South Shores Rd., San Diego, CA 92109)

Loud launch noise and sonic booms from some military space vehicle launches from Vandenberg Air Force Base impact pinnipeds on the mainland and at San Miguel Island, California, and may cause stampedes, temporary threshold shift or, less likely, permanent hearing damage. Maximum fast A-weighted (MFXA) sound levels approximately 4.8 miles downrange during the launch of three Titan IV rockets were 93.2, 92.7, and 93.0 dB; average sound exposure levels were between 98.9 and 101 dB. Harbor seals fled into the water in response but many returned to land within several hours. A sonic boom was recorded at San Miguel Island during one launch. Its peak flat sound-pressure level was 129.5 dB and maximum fast A-weighted sound level was 86.2 dB; virtually all of the energy was below 500 Hz. Pinniped behavioral responses were mild and brief. Predicted overpressures for focused sonic booms from the Titan IV rocket are substantially greater (>150 dB). Noninvasive hearing tests using ABR and OAE techniques are being used to determine if pinnipeds suffer temporary threshold shifts or permanent hearing damage from exposure to those sonic booms.

8:45

4aAB2. Walrus response to offshore drilling operations. Jay Brueggeman (Ebasco Environmental, 10900 N.E. 8th St., Bellevue, WA 98004)

Walrus response to drilling operations in the Chukchi Sea was evaluated between 25 June and 19 October, 1989. Aerial and vessel observations of walruses were conducted at three prospects in conjunction with acoustic measurements of the operations. Walrus response was evaluated before, during, and after they passed the drillsite relative to various sound sources. Over 350 groups comprising approximately 4500 walruses were observed in the prospects. Walrus response was greatest during ice management, when the icebreaker crisscrossed the prospect. Animals moved deeper into the pack ice, where the noise level from the icebreaker was an estimated 15–25 dB above ambient (97 dB). Once ice management stopped or became more focused at the drillsite, walruses began to reoccupy formerly used areas. Under these circumstances, walruses displayed some behavioral responses that rapidly decreased beyond 0.46 km (0.25 nmi) from the icebreaker. Walruses showed little response to other drilling operations. These results show that walruses reacted to icebreaker activities, but responses varied according to the intensity of ice management. This variability offers opportunities to incorporate precautions to minimize disturbance to walruses during future drilling operations.

9:00

4aAB3. Experiments with an acoustic harassment system to limit seal movements. Bruce Mate (Hatfield Marine Sci. Ctr., Oregon State Univ., Newport, OR 97365)

To control the distribution of seals around salmon hatcheries, pond tests were conducted using swept frequencies between 2 and 20 kHz. This did not affect salmonid movements or reproduction. Aperiodic 12- or 17-kHz pulses of varying duration were effective at levels of 187 dB *re*: 1 μPa in reducing seal abundance near several hatcheries and pen aquaculture facilities. A few larger (possibly older) seals habituated or were less sensitive, and foraged with modified techniques. For sea lions, the same system produced a dramatic initial startle response but was otherwise totally ineffective. Many marine mammals react to moving sound sources even if loud stationary sources are tolerated. Early in this experimentation, swept frequencies were eliminated for simplicity. However, the illusion of motion as simulated by Doppler-like sweeps may have been lost in the process. Operant conditioning research suggests that an aversive stimulus is best maintained when used aperiodically. If several stimuli have a deterrent effect, this effect can be sustained longer by intermixing the stimuli to avoid or delay habituation. These principles may also be applicable to intentional harassment and industrial effects.

9:15

4aAB4. Long-range responses of belugas and narwhals to ice-breaking ships in the Northwest Passage. Kerwin J. Finley[a] (LGL Ltd., Environmental Res. Associates, P.O. Box 280, King City, ON L0G 1K0, Canada) and Charles R. Greene (Greeneridge Sci., Inc., Santa Barbara, CA 93110)

WHALE HABITAT IS THE KEY TO FUTURE SURVIVAL

Mate, Bruce R.
Oregon State University, Hatfield Marine Science Center, Newport, Oregon 97365 USA

The future of whales depends upon the continued availability and suitability of critical habitats. For most species, these important areas remain largely unknown. Even for those where habitat has been identified, the reasons that make them attractive to whales are often unknown. In satellite-monitored radio tagging studies we have found many endangered species attracted to upwellings, eddies, river plumes, ice edges, specific water depth and convergence zones.

In gray whale studies conducted in San Ignacio Lagoon in 1979 and 1980, we found individuals stayed for various periods, moved in and out of the lagoon with some regularity often at night, visited other calving areas and stayed close to shore on their migration north to the Bering Sea. The feeding, migration, breeding and calving habitats of the gray whale are the best known of all the whale species. Its nearshore shallow water feeding and calving areas make it easier to study and more vulnerable to man's activities than most whale species. The future survival of all whales is not so much linked to commercial hunting anymore as it is to the deterioration of their critical habitats by human activity.

Mexico's closing of the calving lagoons to whaling is primarily responsible for the species recovery. Mexico has also declared San Ignacio and Ojo de Liebre as whale refuges and the former is in a biome reserve. In both areas, limited tourism has provided income for local people with a strong conservation emphasis for gray whales. Rumored tourism development for Magdalena Bay and industrial development in San Ignacio Lagoon ought to be considered carefully with the same kind of concern and stewardship that Mexico has shown in the past. Gray whales should not lose critical habitat in either instance because of ignorance or benign neglect. Man's activities must be well planned to co-exist without adverse impact if this species and others are to survive.

XIX Reunión Internacional Para el Estudio de los Mamiferos Marinos, 15-18 May 1994. La Paz, B.C.S., Mexico.

Minerals Management Service Information Transfer Meeting, December 1993,
New Orleans, LA

SATELLITE-MONITORED RADIO TAGGING OF SPERM WHALES IN THE GULF OF MEXICO

GULFCET TASKS 5 & 6

Dr. Bruce R. Mate
Kathleen M. Stafford
Hatfield Marine Science Center
Oregon State University

OBJECTIVES

The Minerals Management Service (MMS) funded the GulfCet study to determine the seasonal abundance, distribution and behavior of marine mammals in the Gulf of Mexico. Oregon State University (OSU) was contracted to conduct tasks 5 & 6; the development of depth-sensing radio tags to tag and track sperm whales in the Gulf. The data could be used to determine areas and depths used by sperm whales.

INTRODUCTION

Very little is known about the population of sperm whales in the Gulf of Mexico. Much of our knowledge of numbers and distribution comes from aerial and shipboard surveys (Collum and Fritts 1985; Mullin et al. 1991). Participants of a 1989 workshop sponsored by the Minerals Management Service (MMS), "Sea Turtles and Marine Mammals of the Gulf of Mexico," considered the sperm whale to be the most critical endangered species in the Gulf. It was proposed that, given their size, even a small resident population would play an important role in the ecosystem of the Gulf (Tucker & Assoc. 1989). At one time, the Gulf of Mexico was a whaling ground for the sperm whale (Gosho et al. 1984) but much of the information on catches there has been lumped with data from the southeastern Atlantic.

Collum and Fritts (1985) reported the results of aerial surveys and opportunistic shipboard sightings of sperm whales in the Gulf of Mexico from 1979 to 1981. A total of 59 animals were seen (47 presumed adults or sub-adults and 12 calves). Sperm whales were seen in water 104 m to 2,742 m deep, and in waters over areas of high productivity such as the edge of the continental slope. They proposed that these areas could attract cephalopods, the main prey of sperm whales, and thus influence the distribution of sperm whales in the Gulf.

Mullin et al. (1991) used aerial surveys from 1989 to 1990 to study cetaceans along the upper continental slope off the Mississippi River delta. Sperm whales were the second most common cetacean sighted during their transects. They sighted 43 herds ranging from 1 to 11 whales, for a total count of 91 animals. Like Collum and Fritts (1985), most sightings were in the fall months. In general, the sperm whales seen in this survey were concentrated near the Mississippi River delta in water greater than 600 m deep, and most often in 900 m to 1200 m water. One whale was sighted in water 2,392 m deep. Mullin et al. (1991) believe that their estimates of sperm whale abundance were too low because of the whales' long dive times relative to the aircrafts' time over the survey areas.

TAG DEVELOPMENT

Satellite-monitored (Argos) tags which collect depth information were developed using assemblies from Telonics (Mesa, AZ) and Wildlife Computers (Woodinville, WA). OSU developed the packaging, attachments and software. The tags were successfully tested on ten bowhead whales in the fall of 1992 under MMS funding, Alaska office (Mate and Krutzikowsky 1993).

CRUISE CHRONOLOGIES

Three cruises were undertaken in support of the tagging effort. The first cruise was conducted from 30 September-14 October, 1992. Of four and a half days at sea during this time, we only encountered sperm whales once on 9 October. During four hours we saw 8-10 whales. They demonstrated little reaction to the vessel and no alarm responses were noted when the vessel approached within eight meters. The charter vessel, the R/V McGrail was built for higher speeds and did not maneuver well at the slow speeds required for closer approaches.

The second cruise was from 20 - 31 March, 1993, aboard the R/V Odyssey a 92' sailing vessel owned by the Whale Conservation Institute. OSU sponsored this expedition as a 'proof-of-concept' for future tagging efforts in the Gulf. MMS contributed three tags to this effort. After several days of searching visually and acoustically, 200+ sperm whales were found and tracked for an additional five days and nights. We were able to closely approach whales while using the diesel auxiliary engine. There was no flight response although the whales frequently moved abruptly out of the way of the vessel when the shadow of the boat passed over them or when it came within three meters. On 26 March, we applied a satellite-monitored radio tag to a sperm whale. The tag was approximately 0.5 meters from the dorsal ridge of the animal. The deployment appeared to be complete and there was no startle or flight response by the animal. Unfortunately, no information was returned via satellite from this tag. As the tag had been tested to pressures in excess of 2000 meters and the same type of tags were very successful on Arctic bowhead whales in 1992, we are at a loss to determine why we did not hear from this animal. Of two other tagging attempts, one glanced off the back of the animal's mid-dorsal ridge and one missed by a few centimeters. Both tags were lost.

The third cruise took place from 6 - 29 June, 1993 in the Gulf of Mexico. Survey efforts were concentrated in an area within 100 kilometers south and east of the Mississippi delta. We were aboard the 58' R/V Acadiana, chartered from LUMCON (Louisiana Universities Marine Consortium). We were able to work at sea for 14 of the 24 days. During the course of the charter, we covered 2,331 kilometers of search track line. We surveyed for sperm whales both visually and acoustically. We sued hydrophones from sonabuoys to determine whether whales were present in the survey area. We stopped approximately every 10 miles (based on an effective hydrophone range of five miles) along our track to listen. Two observers were on watch during daylight hours.

RESULTS OF THE THIRD CRUISE

A total of approximately 90 sperm whales were seen during the course of our third cruise. Animals were sighted seven of 14 days at sea and heard on 11 days. On the days whales were sighted, four to 22 individuals were seen. On average, whales were seen at a rate of 0.04 whales per kilometer of track line. Distribution of animals was very patchy. We regularly found animals in an area 70 - 100 km directly east of the southern tip of the Mississippi delta.

The whales we found were surprisingly small; only two were slightly more than eight meters long. This is atypical of sperm whale school structure (see Best 1979). An examination of stranding data supplied by Jim Mead of the Smithsonian Institution suggested that sperm whales in the Gulf are as large as those found elsewhere in the world. We do not think that this was an example of a naturally small-sized population but believe that we were seeing mostly subadult animals. On several occasions we remained in areas with these small whales for several hours but never saw larger animals arrive or surface.

We tagged two sperm whales during this cruise. A satellite-monitored depth-sensing tag was applied to an 8 m animal on 7 June 1993. The tag was applied near the dorsal ridge but was very poorly attached. One message was heard from this tag shortly after deployment. Combined with our previous experience in the Galapagos when an attempt to tag in this region of the back resulted in a deflected tag, we now conclude that the dorsal ridge is particularly tough and an area we will avoid in future tagging attempts. We are also concerned that with small animals,the dorsal ridge may not provide sufficient blubber depth for the anchoring mechanisms.

The second tag, was developed by OSU for the Office of Naval Research (ONR) and provides location only information. It was applied on 11 June to a 7 m sperm whale. This tag was designed to be virtually implantable. The positioning of this tag was good but attachment was incomplete. Specifically, the penetration was not sufficient to engage wires used as the hold-down mechanism. We believe that this tag, too, was lost very soon after tagging.

During the latter half of our cruise, a seismic vessel, the Acadian Commander, and its backup vessel were in the area in which we had regularly found sperm whales, preparing to start a month-long seismic survey. There operations began on 23 June. During the first two days of their operations, sperm whales were not seen within the active seismic area but only around the periphery. From 25 - 29 June we surveyed this same area intensively and found no whales in the seismic area and only four whales in 920 km of searching. This sighting rate of 0.004 whales/km was an order of magnitude less than the overall average prior to the initiation of seismic surveying. Within the seismic area, whale abundance changed significantly from a pre-seismic abundance of 0.092 whales/kilometer (Figure 1) to 0.038 whales/kilometer during the first two days of seismic survey activity (Figure 2) to 0 whales/kilometer on days 3-7 after seismic operations began (p-value <.001, Figure 3). While we do not view the observations we have made to be proof of a cause-and-effect relationship, the significant correlation of these events suggests that further investigation into the potential effects of seismic surveying on the movements and distribution of sperm whales is warranted.

SUMMARY OF FINDINGS TO DATE

+Sperm whales in the slope edge waters off Alabama and Mississippi in the Gulf of Mexico have a patchy distribution.

+Animals observed nearshore (<100 km from shore) were small and considered to be juveniles.

+Sperm whales exhibited no overt signs of disturbance when closely approached by diesel vessels.

+Tag deployment appeared satisfactory when a tag was placed away from the dorsal ridge.

+Active seismic survey vessels may affect the movements and distribution of sperm whales.

FUTURE GOALS

OSU will sponsor an additional field effort on sperm whales in the Galapagos during January-February 1994. We hope to deploy two of each of the depth-sensing and location-only tags. The latter will be modified for a surface attachment, and will have 75% less frontal drag than the former. The remaining MMS funds from the GulfCet program will be augmented by OSU Foundation monies to provide a third expedition to tag sperm whales in the Gulf of Mexico.

REFERENCES

Best,Peter. 1979. Social organization in sperm whales, *Physeter macrocephalus*. Chap. 7. In Winn,HE; Olla,BL (eds.). Behavior of Marine Animals Volume 3: Cetaceans. 1st ed. Vol. 3. Plenum Press, New York, 227-289.

Collum,L; Fritts,TH. 1985. Sperm whales (*Physeter catodon*) in the Gulf of Mexico. The Southwestern Naturalist 30(1), 101-104.

Gosho,ME; Rice,DW; Breiwick,JM. 1984. The sperm whale, *Physeter macrocephalus*. Mar. Fish. Rev. 46(4), 54-64.

Mate,BR; G. Krutzikowsky. 1993. Movements and dive habits of bowhead whales from satellite-monitored radio tags. Alaska OCS Region Information Transfer Meeting Conference Proceedings, January 20-22, 1993, Anchorage, Alaska, pp. 101-102.

Mullin,Keith; Hoggard,Wayne; Roden,C; Lohoefner,R; Rogers,C. 1991. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. OCS study MMS 91-0027, 108 pp.

Tucker and Associates,Inc. 1990. Sea turtles and marine mammals of the Gulf of Mexico, proceedings of a workshop held in New Orleans, August 1-3, 1989. OCS Study MMS 90-0009. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. 211 pp.

BIOGRAPHY

Dr. Bruce Mate is a professor Fisheries and Wildlife at the Hatfield Marine Science Center, Oregon State University. He has studied marine mammals for 25 years and has specialized in the development of technology to track and access behavior of pinnipeds, cetaceans and sirenians. His areas of interest include distribution, behavior, migration and ecology of marine mammals.

Kathleen Stafford is a graduate student at Oregon State University. She has studied sperm whales in the Gulf of Mexico and the Galapagos. Her areas of research interests include dive behavior of sperm whales and acoustic behavior of blue whales.

MOVEMENTS AND DIVE HABITS OF BOWHEAD WHALES FROM SATELLITE-MONITORED RADIO TAGS

Bruce R. Mate and Greg Krutzikowsky
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Bruce R. Mate is a professor of wildlife and oceanography at Oregon State University who has conducted marine mammal research since 1968. He has determined the migration routes of sea lions along the west coast of the United States; investigated heavy metals and organochlorines in pinnipeds; studied marine mammal/fishery conflicts; and pioneered satellite-monitored radio tracking of small and large cetaceans. He has MMS-funded projects on the satellite-monitored movements of bowheads in the Arctic and sperm whales in the Gulf of Mexico.

Twelve bowhead whales (*Balaena mysticetus*) were radio tagged from 30 August to 5 September 1992 off the Mackenzie River delta in the Canadian Beaufort Sea. The purpose of the project was to acquire dive habits and movement data from the end of the open water feeding season in the Canadian Beaufort Sea and similar information on the fall migration west through the Alaskan Beaufort. The tags were Argos (satellite-monitored) radio tags with customized controller boards packaged in a cylinder (2" diameter and 6" long). They were attached by means of a 150# compound crossbow and a subdermal folding barb at each end of the cylinder.

Whales were tagged at close range from a platform extending 2 m over the starboard bow of the 14 m research vessel *Annika Marie*. Tags were located on the back of the whale approximately 2 m behind the blow hole. All tags were applied within a single week to subadult whales in an area of 40 square kilometers.

The tags monitored information on dive durations, depths and temperatures during eight daily summary periods. Each tag transmitted 256 bits of information whenever it surfaced. Without a duty cycle, estimated transmitter life was 32 days. It takes three sequential transmissions to provide a full suite of sensor data.

The movements of eight whales were tracked for periods varying from 4-34 days and distances of 500 km to nearly 5,000 km. Over 12,000 km of movements were tracked during the course of 123 tag days. The longest attachment was confirmed by a message from one tag after 50 days. There was evidence that six of the tags stopped functioning due to low battery power (a monitored variable).

While some individuals stayed in the vicinity of Mackenzie Bay, others concentrated activities around Herschel Island and Demarcation Bay before heading west. The concentration of activity around Herschel Island and Demarcation Bay adds credence to the suggestion that these areas are important feeding areas for bowhead whales prior to the fall migration. Most of the animals spent their time inside the 500 m contour but some went into deeper waters directly north of the Mackenzie Bay/Herschel Island complex. This suggests there is not a highly cohesive migration. Instead, individual whales migrate at their own pace and initiation of the western movement is not from a single well defined environmental cue.

Two whales moved west of Prudhoe Bay. One whale was tracked across the Chukchi Sea following the heavy ice edge to Wrangel Island and then south. This is the first documentation of bowhead migration through the Chukchi Sea and evidence of the importance of the ice as a major migratory cue.

The sensor data acquired from these tags suggest that bowhead whales conduct longer dives and spend a higher percentage of their time submerged than any other species of baleen whale. Specific information on maximum duration of dives, maximum surfacing periods, deepest dives and percentage of time spent at different dive depths is presently under analysis and will be part of the project's final report to Minerals Management Service.

Tags identical to those used on bowhead whales will be applied to sperm whales in the Gulf of Mexico in 1993. Sperm whales are reputed to be the longest and deepest diving of all cetaceans. The sperm whale research is sponsored by the Gulf Region of Minerals Management Service.

QUESTIONS AND DISCUSSION

DON HANSEN: You mentioned about that one anomaly, where whales surface in ice to breathe but the transmitter is not exposed and results in the illusion of longer dives and less time at the surface. I was wondering whether that could be occurring more often? In other words, whales, in fact, may be spending more time on the surface rather than what you said, five percent, due to where the tag is located on the whale versus what the whale is doing?

BRUCE MATE: Yes, you are right. There is a potential bias, even in open water, but we have enough information in open water from this and other species to feel confident that there is a real difference between bowheads and other species. We actually locate this tag a little differently on the bowhead than we would on another baleen whale species. On other baleen whales, we would locate the tag 1-2 meters behind the blow hole. Bowheads have a conspicuous neck that wouldn't surface in that area, so the tag is located farther back. Our field observations suggested that the tag surfaced quite regularly. The presence of a high proportion of short duration dives also suggests we are not missing much. If, for instance, the tag were only exposed as the whale fluked up on a "terminal dive," we would not have seen short dives in open water. We are confident that bowheads really are substantially different, both in the durations of dives and percentage of time submerged. But there is the potential for some bias, such as I mentioned in the ice. And I would emphasize again, I am sharing with you preliminary information and it should not be quoted until our analyses are completed. There is about an 18% error rate in Argos data and we have rushed to eliminate much of the errored information to share this preliminary evaluation with you today, but we are not done.

CALEB PUNGOWIYI: Could the battery situation be developed where you could track these animals for a longer period of time, like out to their wintering areas?

BRUCE MATE: Yes, we will get to that point. We originally planned to use different software to reduce the transmission rate to 8 hr/day. That would have probably tripled the duration of operation from transmitting 24 hr/day as we did this summer. The smaller prototype unit I showed you has less batteries, but will have a location-only capability with a very short transmission so we can extend its operation to four to six months; I believe hydrodynamic drag contributes a lot to tag loss, especially when large animals travel at high speeds routinely. This would promote pressure necrosis and tag loss. By the way, we have seen right whales in the North Atlantic after they lost their tags, and there was little swelling, no tissue sloughing, and no significant scarring. We are quite pleased that whales do not react adversely to tagging. We believe the tags do not cause the whales problems, and thus we are collecting data from healthy "normal" individuals.

bowhead 1192

BOWHEAD 1992 LOCATION INFORMATION

PTT #	# ORIG LOC	# FINAL LOC	TOTAL DAYS TAGGED	TOTAL DISTANCE (KM)	MEAN SPEED (KM/HR)
10824	278	232	34	4786.0	5.9
10825	39	28	11	914.7	3.5
10826	18	12	4	494.0	5.1
10827	81	67	12	1131.6	3.9
10828	43	40	10	784.0	3.3
10830	65	47	11	1633.1	6.2
00828	16	14	24	856.4	1.5
00831	21	17	17	1484.9	3.6
TOTALS	**561**	**457**	**123**	**12084.7**	**4.1**

DeMaster

5 May 94 draft
DISCUSSION OF TEXT TONIGHT AT 7:00pm (meet in front of plenary hall). DD.

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A Potential List of Issues to be Raised at an Intersessional Workshop on the Effects of Anthropogenically-Induced Environmental Change on Cetacean Stocks

D. DeMaster, C. Tynan, P. Hammond, S. Swartz, C. Clark, T. Smith, R. Brownell, D. Palka, and B. Mate

I. Introduction

The purpose of this working paper is two fold: 1) to provide an annotated list of documents presented to this meeting that address the topic of how environmental changes may adversely affect cetacean stocks and 2) to provide a potential list of issues for discussion concerning the effects of environmental change on cetacean stocks. It should be recognized that the focus of these discussions is to develop terms of reference for an intersessional workshop that has tentatively been scheduled for December 1994 in La Jolla, CA.

II. Background

At its Annual Meeting in 1992, the Commission decided that the Scientific Committee should establish a regular agenda item to address the impact of environmental change on whale stocks, that it should initiate the exchange of information on this topic with relevant organizations, and that it should develop practical means to address the questions raised by these exchanges. SC/45/SHBa21, SC/45/O 16, and SC/45/O 17 were presented at the 1993 Scientific Committee meeting in response to the Commission's request.

In SC/45/SHBa21 the author suggested initiating modelling studies as a preliminary effort and recommended a workshop be convened to identify baleen whale life history parameters that may prove informative regarding potential effects of environmental change on stocks of Antarctic whales. Further, he noted that it would be necessary to determine the magnitude of any likely responses of whale stocks to environmental changes and whether this change was detectable with currently available sampling techniques.

In SC/45/O 16 the author presented a review of the most significant environmental threats to cetacean stocks in high-latitude marine ecosystems, with special reference to the Barents and Norwegian Seas. These included organochlorines, heavy metals, petroleum hydrocarbons, nuclear wastes, ozone thinning, climate change, over-fishing, and other minor threats. The author noted three areas of concern: 1) the absence of information on the physiological and pathological effects of environmental threats to cetaceans, 2) the absence of information on global emissions of non-biodegradable pollutants and their levels in the environment, and 3) the present inability to predict the synergistic effects of these threats to marine organisms.

In SC/45/O 17 the authors summarized the information available on the incidence of organochlorine compounds in marine organisms from the northwest Pacific Ocean. No information was reported for minke whales from this region; however, the authors postulated that concentrations of organochlorines is comparable to levels reported in small cetaceans.

In discussion at the 1993 meeting, the Committee noted the broad nature of the topic and its relevance to the long-term management and conservation of whales. It further concluded that this topic could logically be divided into two types of environmental changes: 1) those arising from climate changes, where the area of potential impact is large and 2) those arising from local disturbances, where the area of potential impact is small (i.e., the impact is local). However, in spite of concerns regarding the effects of environmental change on cetacean stocks, there was not sufficient concern to cause the Committee to change its position relative to the RMP.

At its 45th Annual Meeting (1993) the Commission adopted a Resolution on the Environment and Whale Stocks (RIWC 44:35). In it the Commission decided that the Scientific Committee should give priority to research on the effects of environmental change on cetaceans and that a special workshop should be convened before the 47th Annual Meeting. Further, the Scientific Committee and Contracting Governments were to consider inviting participants to the 1994 Scientific Committee (SC/46) meeting with expertise in addressing the impact of environmental changes and the impact of such changes on cetaceans.

At the Intersessional Working Group meeting on a Sanctuary in the Southern Ocean (February 1994) several delegations believed that the RMP should be re-evaluated in light of the potential for anthropogenically-induced environmental change. In response to these concerns, the acting Chair of the Scientific Committee noted that "there was limited consideration of environmental problems incorporated into the robustness trials of the RMP. The RMP was found to be robust to a 50% decline in carrying capacity over a 100 year period, and to a 50% die-off occurring at random as might result from a disease epidemic". A number of delegations considered that a sanctuary would facilitate further study of climate change and ozone depletion. Other delegates stated that a sanctuary was unlikely to provide new grounds for study.

As noted earlier, both the Commission and the Scientific Committee recognized that all cetacean stocks could be potentially threatened by anthropogenically-induced environmental changes. The following summarizes the information presented in the documents submitted to the 1994 Scientific Committee meeting concerning this topic and presents a tentative list of topics to be discussed at the intersessional workshop in December 1994.

III. Annotated List of Papers

Impacts of Global Climate Change

SC/46/O 3. Predictions of Antarctic climate and ecological response to increasing CO_2 and decreasing ozone (Tynan and DeMaster).

Concerns over CO_2-induced global warming and chlorine-catalyzed ozone depletion over Antarctica are discussed. Further, model predictions for climate change in the Southern Ocean and the effects of increased exposure of marine life to UV-B radiation are presented.

SC/46/O 4. Responses to the IWC45 resolution on research on the environment and whale stocks (Intergovernmental Oceanographic Commission (IOC), International Council for the Exploration of the Sea (ICES), Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), UK-Ministry of Agriculture, Fisheries and Food, World Meteorological Organization (WMO), United Nations Environment Programme (UNEP)).

The documents of these six organizations include support for: the development of long-term global and regional monitoring systems to assess the ecological impacts related to climate change, international concerted efforts to understand the processes of the Southern Ocean and its role in climate change, the strengthening of existing international research programs in co-operation with other international organizations, the exchange of information on the effects of environmental change in the Antarctic region, the establishment of oceanographic and environmental models which can help predict effects of climate and other changes on living marine organisms (including factors which determine the magnitude and variation of primary production in the Southern Ocean).

SC/46/O 7. Effects of environmental change on cetaceans: The ecology of the Southern Ocean (Marin).

The importance of the effects of global climate change on the Antarctic marine ecosystem is addressed. Several examples of the complex relationship between changes in the biological and physical environments of the Southern Ocean are presented (i.e., the interannual variation in the extent and duration of ice cover and the abundance of krill). Development of mathematical models and the collection of long time series are suggested to elucidate the effects of environmental change on cetaceans.

SC/46/O 15. A framework for the comprehensive assessment of threats to cetaceans: An illustrated holistic approach (Brown).

The main premise is that all known threats to cetaceans must be considered collectively in their management because of the existence of synergistic interactions among threats. Five general categories of threat are identified: 1) pollution (organochlorines, heavy metals, petroleum hydrocarbons, and nuclear waste), 2) habitat degradation (over fishing, euthrophication, anthropogenic noise), 3) environmental change (ozone depletion, global warming), 4) deliberate killing, and 5) expected (i.e., anticipated) and unknown threats.

SC/46/O 17. Information note on the status of environmental change studies relevant to the marine environment supported by UNEP (Borobia).

The paper presents a summary of programs directly supported by the Oceans and Coastal Areas Program, UNEP, on climate change. Also presented is a summary of the general state of knowledge concerning climate change (i.e., ozone depletion and global warming). Regarding the Southern Ocean, the author noted that the predictions of ocean-atmosphere models (CGCMs) are generally similar to predictions produced using equilibrium models, except that transient simulations show reduced warming over the North Atlantic and Southern Oceans (see also SC/46/O 3: 2).

SC/46/O 18. A conceptual model of the Antarctic marine food web based on an ecosystem approach to resource management (Lascara and Hofmann).

A set of coupled submodels are presented as a conceptual model for organizing the processes that determine the environmental variability experienced by krill into three major categories: 1) direct influences of the physical environment, 2) trophodynamic relationships, and 3) active redistribution by krill in response to local conditions. The first two categories represent the physical and biological factors typically included in models used to simulate variability in the distribution of zooplankton; while the third category is rarely included in such models.

SC/46/O 28. Towards a framework for investigating the effects of environmental change on whale populations (Hammond and Zheng).

Two approaches are discussed. The top-down approach involves investigating whether distribution and abundance can be described in terms of biological and physical oceanographic and environmental data. A preliminary analysis on predicting Southern Hemisphere minke whale abundance from purely physical data is presented. The bottom-up approach involves investigating whether the foraging and breeding behavior of individual animals can be adequately described by models utilizing oceanographic and environmental data. This work would require the ability to track free-ranging cetaceans using satellite telemetry.

Impacts of Local Anthropogenic Effects

SC/46/O 8. Cetaceans and contaminants: reasons for concern? (Reijnders). Not available for review.

SC/46/O 12. Planar chlorinated hydrocarbons in New Zealand marine mammals (Jones et al.).

Results are presented from analyses of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibensofurans (PCDFs), and specific polychlorinated biphenyl (PCB) congeners in the blubber of Hector's dolphin and other open ocean species of cetaceans stranded on the coast of New Zealand. Concentrations of PCB congeners were highest in the nearshore carnivore (Hector's dolphin), intermediate in open ocean carnivores (beaked whales and open ocean dolphins) and lowest in open ocean baleen whales (minke, blue, pygmy right whale). The concentration of planar chlorinated hydrocarbons (PCHs) in cetaceans was related to both food habit and proximity to the coast. It was noted that the sources of chlorinated PCB congeners reported for open ocean cetaceans are believed to be derived from the atmosphere.

SC/46/O 14. The significance of pollution for marine cetaceans (Moscrop and Simmonds).

The precise nature of the threat to cetacean stocks caused by pollution cannot always be defined, but the magnitude of at least some pollutants are increasing. Although the threats are impossible to quantify, significant impacts of marine pollution (e.g., organochlorines, heavy metals, oil, polynuclear aromatic hydrocarbons, persistent synthetic marine debris and sewage effluent) are discussed for cetaceans and other marine organisms.

SC/46/O 15. A framework for the comprehensive assessment of threats to cetaceans: An illustrated holistic approach (Brown).

(see above)

SC/46/O 16. Requirements for a comprehensive assessment of pollution in cetaceans: Quantification, evaluation and absolute threat of pollutants (Brown).

To redress the absolute pollutant threat to cetaceans the most up-to-date information must be compiled, analyzed, and acted upon. In view of our current lack of understanding concerning the effects of pollution
on cetaceans, it is recommended that the IWC carries out a comprehensive review of pollution and other threats to cetacean populations before making decisions regarding the moratorium on commercial whaling.

SC/46/O 20. An overview of the concentrations and effects of heavy metals in cetacean species (Bowles).

Data are presented on the biomagnification rates, accumulation and concentrations of heavy metals in cetacean species. Levels tended to be lower in baleen whales than toothed cetaceans, primarily due to feeding lower on the food chain by the former. Pollution levels were also reported to vary geographically. Finally, a geographic comparison of mercury concentrations in toothed whales is presented.

SC/46/Information. Organochlorine and metal contaminants in baleen whales: A review and evaluation of conservation implications (O'Shea and Brownell).

Concentrations of organochlorine and metal contaminants in tissues of baleen whales are reviewed. The authors noted that there is no firm basis
to conclude that contaminants have adversely affected populations of baleen whales. The authors recommended that reducing human-related mortality and protecting the habitat of baleen whales should be a higher priority for research and management than gathering additional information on contaminants. However, the authors cautioned that, despite a lack of a strong basis for inferring the existence of reproductive effects from PCBs in baleen whales (and presumably other contaminants), much remains to be learned about toxicity in mammalian wildlife.

III. Potential Agenda Items

The following list of agenda items was generated based on findings and recommendations contained in RIWC 44, SC/45/SHBa 21, SC/45/O 16 and 17, and the papers presented at this meeting. It should be noted that the effects of environmental change on cetacean stocks may be both species-specific and area-specific. Therefore, the reliability of broad scale generalizations is questionable. Further, the availability of existing information and the probability of successfully collecting sufficient data to draw specific conclusions varies widely among the issues listed below. Concerning the development of terms of reference for a workshop, the order of issues that follows has not been prioritized. Finally, comments at this meeting regarding the merit of discussing all of these issues or a subset of these issues at a workshop would be useful.

1. Ecological ramifications of global warming based on prey preference, primary feeding grounds, and geographic distribution on-
   a) baleen whales in the Southern Ocean,
   b) toothed whales in the Southern Ocean,
   c) baleen whales in the North Atlantic,
   d) baleen whales in the North Pacific,
   e) other cetaceans.

2. Ecological ramifications of ozone depletion based on habitat preferences, cetacean prey (krill), migrational patterns, feeding behavior, and segregation of animals by age and sex on-
   a) expected scale of spatial and temporal response,
   b) baleen whales in the Southern Ocean,
   c) toothed whales in the Southern Ocean,
   d) other cetaceans in other oceans,

3. Direct effects (e.g., i~~ncreased incidence of carcinoma~~s) of UV-B radiation on-
   a) baleen whales in the Southern Ocean,
   b) other cetaceans.

4. Effects of pollution (e.g., organochlorines, heavy metals, oil, polynuclear aromatic hydrocarbons, persistent synthetic marine debris and sewage effluent) on-
   a) coastal delphinids,
   b) harbor porpoise,
   c) other toothed whales,
   d) baleen whales.

5. Effects of incidental mortality related to fisheries on-
   a) coastal delphinids,
   b) harbor porpoise,
   c) other toothed whales,
   d) baleen whales.

6. Ecological ramifications of reducing the availability of prey through commercial fishing on-
   a) coastal delphinids,
   b) harbor porpoise,
   c) other toothed whales,
   d) baleen whales.

7. Effects of human activities (e.g., seismic operations, shipping, acoustic tomography, development, etc) on-
   a) coastal delphinids,
   b) harbor porpoise,
   c) other toothed whales,
   d) baleen whales.

8. Commercial whaling
   a) Direct effects
   b) Indirect (e.g., competitive) effects

9. Development and selection of methodology to address potential effects of environmental change on cetaceans
   a) predictive models
   b) long-term monitoring
   c) review existing data
   d) in situ biological dosimeter for UV-B radiation

APPENDICES

Appendix 1. Swartz and Clark- Sources and potential effects of "noise" disturbance.

Appendix 2. Mate- Concerns over critical habitat for gray whales (ref. 5-year Research and Management Plan for Gray Whales [required as part of delisting under ESA].

Appendix 3. ??- Concerns over increased number of stranded bottlenose dolphin in the Gulf of Mexico since 1992 (see US progress report- reference to distemper virus and possible relationship to pollution levels in areas where strandings have occurred).

Appendix 1.

SOURCES AND POTENTIAL EFFECTS OF NOISE DISTURBANCE

Steven L. Swartz and Chris Clark

Sources of noise

Many wildlife species, including marine and terrestrial mammals and birds, are subject to continual auditory input from their environment and from other species including conspecifics. Noise produced by various human activities contributes to the overall acoustic environment and has the potential to interfere with animals' ability to perceive their habitat and communicate with each other. These anthropogenic noises are a by-product of: aircraft, particularly helicopters; construction equipment
(e.g., trucks, bulldozers, etc.); explosives (e.g., used in seismic exploration and mining activities); ships (e.g., tugs, barges, icebreakers, tankers, and fishing vessels); onshore and offshore drilling activities; logging; and other human activities.

Effects of noise

Effects on marine and terrestrial species may include acute changes in behavior such as flight, curious attraction and general annoyance, interference with communication or echolocation, and changes in metabolic rate (e.g., heart rate) which may affect physiology. These in turn can affect survival and reproduction.

Predator and prey alike depend upon sounds to catch prey and to avoid being caught, respectively. For many species the breeding and feeding grounds to which they annually migrate, and represent a critical links in their natural history. Disruption of vital activities in the short-term and possible abandonment of important feeding, breeding or other secondarily important areas over the long-term resulting from exposure to noise could potentially affect the stability of some populations.

It is well established that the acoustic sense of many marine mammals (e.g., pinnipeds and cetaceans) constitutes their primary sensory mode because sound rather than light travels well through water. Marine mammals use naturally produced sounds as ques to navigate through their environment and some species produce active calls (vocalizations) to communicate during migration, breeding, or feeding. Others actively echolocate to find food and to "see" in turbid water. Many marine mammals live in ice-covered waters for all or a portion of the year. The ice environment is one of the most dynamic acoustic environments known, with ice movement and breakage producing at time explosive underwater noise. Despite their probable familiarity with these loud natural noises, it has been demonstrated that gray whales, bowhead whales, and beluga whales all respond to varying degrees to noise associated with offshore oil and gas exploration and development activities. What is not clear is the potential for chronic changes in these species' behavior or effects on survival and reproduction that may result from long-term exposure to noise from these sources.

The potential significance of the effects of human noise relates to the scale and scope as well as the nature of the activity. For example, the noise disturbance associated with one aircraft overflight or offshore seismic survey may have no significant long-term effect, but the cumulative effects of many such activities compounded over time in the same area may have a significant influence on the use of that area by wildlife and on the animals themselves. Human development that produces noise should be accompanied by research to better determine the physical, physiological, and psychological effects of noise and by monitoring programs to verify predicted effects of noise on wildlife and to detect any unforseen effects in advance of disadvantaging populations of species that depend on the affected environments.

Sources of Noise:

Aircraft, particularly helicopters
Construction Equipment (e.g., trucks, bulldozers, etc.)
Explosives (e.g., seismic exploration and mining activities)
Ships (e.g., tugs, barges, icebreakers, tankers)
Drilling, onshore and offshore
Other human activities (e.g., use of snowmobiles for recreation and transportation)

Effects:

Acute:
- Fright, stampedes
- Abandonment and avoidance of feeding, migratory, and breeding areas

Chronic:
- Masking of calls and ambient sounds
- Annoyance (e.g., habitual behavior modification)
- Stress with its physiological side effects
- Abandonment and avoidance of feeding, breeding areas
- Attraction of polar bears (e.g., to work camps, drill sites)

SATELLITE-MONITORED MOVEMENTS AND DIVE PATTERNS OF RADIO-TAGGED NORTH ATLANTIC RIGHT WHALES, *Eubalaena glaciales*

Mate, B.R.[1], S.L. Nieukirk[1], S.D. Kraus[2], R.S. Mesecar[1] and T.J. Martin[1]
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Seven North Atlantic right whales, tagged in the Bay of Fundy (BOF) with satellite-monitored (Argos) radio transmitters, traveled at least 9,590 km between 366 locations. In 43 days, a female with a calf traveled 3,800 km and an adult male traveled 3,000 km. Both returned to the BOF, changing our previous notion of BOF residency times. A preference for slope edges increased the whale's risk of ship collisions. The combined averageswimming speed for all animals was 3.7 km/hr.
Data were collected on 92,693 dives (x = 86 ± 48s). Whales were submerged most of the time (x = 78 ± 13%) although some individuals spent long periods at the surface. One animal (instrumented with a pressure sensor) dove routinely to the bottom in water up to 200 m deep. There was little reaction to tagging and no evidence of scars or swelling after tag loss.
Satellite tracking and monitoring is a powerful tool for studying free-ranging whales.

RASTREO POR SATELITE DE PATRONES DE MOVIMIENTOS Y DE BUCEO DE BALLENAS FRANCAS DEL ATLANTICO NORTE, *Eubalaena glacialis*, CON RADIO-MARCAS

Siete ballenas francas del Atlántico Norte, marcadas en la Bahía de Fundy (BOF) con radio transmisores para seguir con satélite (Argos), viajaron por lo menos 9,590 Km entre 366 localidades. En 43 días, una hembra con su cría viajó 3,800 Km, mientras que un macho adulto viajó 3,000 Km. Ambos regresaron a BOF, cambiando nuestro conocimiento previo de tiempos de recidencia en BOF. Las prefefencia de las ballenas por bordes con pendientes, incrementó el riesgo de colisiones con barcos. El promedio combinado de velocidad de nado de todas las ballenas fue 3.7 Km/hr.
Se colectaron datos en 92,963 buceos (x = 86 ± 48s). Las ballenas estuvieron sumergidas la mayor parte del tiempo (x = 78 ±13%) aunque algunos individuos permanecieron en la superficie por períodos prolongados. Un animal (provisto de un sensor de presión) realizó inmersiones rutinarias al fondo en aguas de más de 200 m de profundidad. Existió una mínima reacción al marcado y no hubo evidencias de cicatrices o hinchazón después la pérdida de las marcas.
El marcado y seguimiento con satélite es una herramienta poderosa para estudiar ballenas en su medio natural.

Further Thoughts on Tourism and Other Developments in Gray Whale Critical Habitats

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The main point of this discussion is to emphasize that there are a range of factors and options to be considered when proposing development in or around critical habitats for wildlife to assure that adverse consequences are avoided. Development certainly can (and in most cases will) occur, but the emphasis should be to assure that it is thoughtfully planned and that development plans incorporate scientific information and advice on the habitat requirements of the wildlife (*e.g.*, gray whales), and build on the lessons that have been learned from places and times where people were less concerned with the effects of development on wildlife (*e.g.*, San Diego Bay).

ASWP4 notes that the eastern Pacific stock of gray whales has lost access to some of its former coastal habitat in historical times, and the importance of evaluating the effects of these lost habitats for future gray whale population recovery. The failure of gray whales to reoccupy San Diego Bay is an example of a former gray whale lagoon habitat that is no longer available to gray whales due to industrial growth. In comparison, the gray whales breeding lagoons along Baja California, Mexico are relatively undeveloped and continue to be utilized extensively by gray whales during the winter months. Mexico recognized the value of conserving the gray whale population and the unique natural resources on which they depend in Baja California - the breeding lagoons. Mexico has put a high priority on these critical gray whale habitats, and has given some gray whale breeding and calving areas "wildlife refuge" status and included them inside a biosphere reserve.

The largest single gray whale breeding lagoon, Laguna Ojo de Liebre (Scammon's Lagoon) has been the site of the world's largest solar salt-production operation for many decades. This industry has successfully co-existed with much of the marine wildlife of the region, including gray whales in the winter, largely because the lagoon's vast interior provides sufficient space for the salt-shipping operations and the whales. The smaller Laguna San Ignacio to the south of Ojo de Liebre was the location of the beginning of commercial whale-watching since the mid-1970s and, with the exception of local fishing, whale-watching has been the only commercial activity in this lagoon. Despite its smaller size, whale-watching and local fishing has also co-existed with the gray whales and other marine wildlife.

Two of us (Mate and Swartz) studied gray whales in Laguna San Ignacio between 1977 and 1985 and, based on these experiences, we offer several observations on the balance between whale-watching tourism, local fishing, and the lagoon's wildlife. During this period of time, whale-watching tourism and commercial fishing appeared to co-exist well with the wildlife of Laguna San Ignacio (Jones and Swartz 1984). This was due largely to the unique characteristics of this lagoon, the nature of the whale-watching activity there, and the regulations put in place by the Mexican government to control human activities that occur within the lagoon during the winter (See Appendix A).

There are currently proposals to plan development of a solar salt-production operation near to Laguna San Ignacio. Plans for development in the vicinity of Laguna San Ignacio, or within similar habitats or other protected areas, should consider past experiences and "lessons learned" from other countries and in other areas in order to incorporate the knowledge acquired by these experiences when formulating new regulations or when implementing existing regulations for these habitats. In this regard, monitoring of potential impacts from existing activities, such as whale watching and fishing, should continue to identify and to avoid detrimental consequences.

In order to plan development that will be compatible with the conservation gray whales and their critical habitats, both the effects of past and current potential impacts of development need to be evaluated. In the case of the gray whale breeding lagoons of Baja California, the key goal, as we see it, is to protect and to maintain the integrity of the lagoon habitats by:

(1) careful comprehensive planing of any development to accommodate the needs of developers and of the wildlife (*e.g.*, gray whales); and,

(2) implementing an ongoing research and monitoring program that will allow detection and analysis of any changes in the use of the lagoon by gray whales that could be associated with development, including existing levels of tourism and fishing.

In this way the benefits of both economic development and the maintenance of a unique wildlife resource could be achieved.

Appendix A

Factors Unique to Laguna San Ignacio That have Encouraged the Maintenance of the Marine Ecosystem

1. There was not a large human population using the area as tourism developed so there was (and still is) a relatively low effect from direct or indirect activities (*e.g.*, sewage, pollution and in water structures);

2. Because of its remote location and a permit system to regulate visitation, the numbers of tourists are (and have been) limited (no more than 2 vessels at a time and presently 3 licensed land operators);

3. Because of its relatively small size and the importance of the upper lagoon to females with calves (Jones and Swartz 1984), the upper innermost two-thirds of the lagoon is a closed area during the winter and is off limits to all tourists;

4. The skiff operators bringing tour groups to the area have been reasonably stable, providing for experienced skiff (ponga) drivers;

5. With closure of the lagoon to commercial fisheries during the winter whale season, local fishermen have assumed skiff operation activities for tour operators, and there has been a good exchange of information with the previously experienced skiff drivers (essentially a guide training program);

6. The local skiff drivers have formed an organization which limits access (prevents too many skiffs), making the available business (# of customers/boat) economically viable for those drivers (3 skiffs/visiting vessel or land operation);

7. This transition has promoted local support for the unique nature of the lagoon ecosystem and for the conservation of the whales now that whale-watching provides a source of income for the lagoon residents.

8. Both land and boat based tour groups are always accompanied by naturalists who explain the natural history of the whales and the lagoon habitat, and other natural resources in the area (birds, mangroves, desert ecology, fishing, etc) so there is a broader focus than just whales;

9. The naturalists prepare visitors with expectations that do not overly emphasize the likelihood or importance of a "hands on" experience with "friendly" gray whales, but instead focus on behaviors, their natural history, and the importance of the lagoon as a critical habitat for the whales and other wildlife;

10. There is an attempt to have a naturalist aboard each tour vessel or with each land-based excursion group who is bilingual and that can communicate in the appropriate language of the visitors to the lagoon; and,

11. Laguna San Ignacio is an undeveloped natural area where there have been no permanent physical modifications or developments in the lagoon (marinas, hotels, industry).