report

Workshop on Research Needs for the Conservation and Management of Cetaceans in the Pacific Islands Region

Honolulu, Hawaii

June 22 – 24, 2005

Pacific Islands Fisheries Science Center

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National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

PIFSC Mission

The mission of the PIFSC is to conduct high quality, timely research to support the stewardship of fisheries resources, protected species, and ecosystems in the central and western Pacific Ocean.

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introduction

More than 20 cetacean species are known to exist in the Pacific Islands Region, which encompasses the U.S. Exclusive Economic Zone, or EEZ (waters out to 370 km from shore) around the entire Hawaiian Archipelago, Johnston Atoll, Kingman Reef and Palmyra Atoll, Baker and Howland Islands, Jarvis Island, American Samoa, Wake Island, Guam, and the Commonwealth of the Northern Mariana Islands, totaling some 5.8 million km^2 of ocean. Many of the species present are poorly studied throughout their range and virtually unstudied in large portions of the Pacific Islands Region. NOAA Fisheries (National Marine Fisheries Service, NMFS), a branch of the U.S. Department of Commerce, has lead-agency responsibility for cetaceans under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. Heretofore, the agency's Southwest Fisheries Science Center (SWFSC) in La Jolla, California, and the NMFS regional office in Long Beach, California, were responsible for conducting management-related research and providing cetacean stock assessments throughout all U.S. waters of the temperate and tropical Pacific Ocean. Establishment of the Pacific Islands Region within NMFS in April 2003 initiated the devolution of those responsibilities within the region to the Pacific Islands Regional Office (PIRO) and Pacific Islands Fisheries Science Center (PIFSC) in Honolulu, Hawaii. It was expected that the transition of the research component from SWFSC to PIFSC would be gradual and that collaborative work between the two centers would continue for a considerable time into the future.

As an initial step in the pursuit of its cetacean research and assessment mandate, the PIFSC convened a workshop of experts to review and assess what is known about cetaceans in the Pacific Islands region, identify important gaps in knowledge, and provide direction for future research. The ultimate goal is to develop a comprehensive cetacean research plan for the region, and this workshop report is intended to provide essential background to the planning process. The workshop was held from June 22 – 24 2005 at the Hawaiian Islands Humpback Whale National Marine Sanctuary and Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve Offices in Hawai´i Kai, Honolulu.

Participation was by invitation, but every effort was made to include representation from existing cetacean research programs in the region that have displayed a commitment to publication of research findings in the peer-reviewed scientific literature (Annex 1 – list of participants). In addition to researchers, individuals involved in management decision-making and implementation, both regionally and nationally, were present.

Andrew Read chaired the workshop and Randall Reeves served as rapporteur.

The emphasis of the workshop was on information sharing, and therefore the bulk of the time was devoted to presentations, followed by question and answer sessions (Annex 2 – agenda). On the afternoon of the third day, participants listed and ranked the various research topics or tasks that were considered high and medium-high priorities.

This report consists of (1) brief summaries of the presentations, (2) substantive points raised in the ensuing question and answer sessions, and (3) a section describing the agreed research priorities.

Summaries of Presentations and Question and Answer Sessions

The size and configuration of the Pacific Islands region signify that the center's research program must consider issues in both the Northern and Southern Hemispheres and interact with a wide variety of national and international jurisdictions. To date, 23 different cetacean species have been documented in the region, and these include both migratory and resident populations. Initial tasks for the program are to (1) assess the available resources for carrying out research, (2) build partnerships, (3) develop a long-term research plan that incorporates stakeholder inputs, (4) initiate projects, and (5) carry out stock assessments as a top priority.

Regarding item (1), the 68.3-m converted surveillance vessel *Oscar Elton Sette* provides a quiet, well-equipped research platform, with onboard accommodation for up to 18 scientists and 30-day endurance. Small boats are available for deployment from the *Sette* to allow close-up work with marine mammals. One staff biologist (Johnston) has a full-time mandate to conduct and coordinate research on cetaceans, and he is supported part-time by four other staff members. Some potential exists for expansion once the Protected Species Division moves to its new offices on Kapiolani Avenue.

Regarding item (2), a variety of ongoing partnerships will be consolidated and expanded in the coming years. These include continuing collaborations with scientists at the Southwest Fisheries Science Center (*e.g.*, Barlow, Forney, Chivers), a graduate student currently studying spinner dolphin genetics in the Northwestern Hawaiian Islands (Kimberly Andrews), the Hawaiian Mapping Research Group at the University of Hawaii, the University of Hawaii's Sea Grant program (fishery interactions), oceanographers at the PIFSC (*e.g.*, Polovina), Scripps Institution of Oceanography in California (*e.g.*, Hildebrand), Cascadia Research Cooperative in Olympia, Washington (Baird), and the Pacific Islands Regional Office (Yates) which provides links to management. Numerous additional partnerships are anticipated.

Regarding item (3), a first step was taken when the Marine Mammal Commission held its annual meeting in Kailua-Kona in October 2004. There, a number of key issues and topics were identified (for details, see Marine Mammal Commission, 2005). For example, much of the basic information needed for stock assessment—"the foundation for management" (Ibid., p. 7)—is missing for most of the Pacific Islands Region. Therefore, a top priority of the PIFSC must be to obtain more and better data from throughout the region on cetacean stock identification, abundance and trends, and levels of serious injury and mortality due to human activities (particularly fishing). To that end, the PIFSC has stated its intention to: (1) conduct surveys in those areas with identified needs; (2) employ passive acoustic monitoring to assess seasonality of occurrence and plan survey coverage; (3) maintain and, if possible, expand ongoing photo-identification and biopsy sampling; and (4) conduct visual and acoustic line transect surveys where (and when) applicable. Concerning the last of those points, it is anticipated that the *Sette* will soon be equipped with a towed acoustic array.

Dedicated cetacean or joint (collaborative) ship time on the *Sette* has been arranged as follows: 74 days in 2006, 86 in 2007, and 128 in 2008. The current intention for 2006 is to conduct joint monk seal/cetacean work around the Hawaiian Archipelago (providing an opportunity to investigate cetaceans in the Northwestern Hawaiian Islands) and joint cruises with the National Ocean Service in Johnston Atoll and with oceanography collaborators (Polovina and Musyl) around American Samoa. In addition, a cetacean survey of the Johnston, Palmyra, and Kingman EEZs is planned in collaboration with the SWFSC in 2005. To take full advantage of these opportunities for shipboard work, the PIFSC will need to recruit and support more trained observers than are presently available in-house.

The Marine Mammal Commission identified the incidental mortality of false killer whales in longline gear in waters around both Hawaii and Palmyra Atoll and the harassment of spinner dolphins by tour operations (including swim-with-the-dolphins programs) as management issues that require immediate research

(and management) attention. Also, the SPLASH program (Structure of Populations, Levels of Abundance, and Status of Humpbacks) and the Hawaiian Islands Stranding Response Group were cited by the Commission as initiatives that need, and deserve, stable and adequate funding.

In the discussion following Johnston's presentation, participants emphasized the importance of rigorous evaluation of research needs and resource limitations, given the evidently extreme imbalance between the two. There is an obvious danger of spreading the center's meager resources too thinly, but also of putting too much emphasis on only one or several areas and failing to address important issues in other areas. One possible approach would be to establish a rotating schedule of surveys to provide sequential coverage of various regional sectors. Other suggestions included the following:

- Consider using density estimates obtained from surveys in Hawaiian waters to infer densities (and species compositions) in other parts of the region with similar biophysical characteristics.
- Take advantage of platforms of opportunity (e.g., Coast Guard vessels) to obtain at least rudimentary data on species occurrence.
- Stratify survey effort to emphasize features of special interest (e.g., oceanic fronts).
- Following the suggestion that the remote-sensing capabilities of the National Environmental Satellite, Data, and Information Service (NESDIS) might be of use in various ways, Johnston called attention to the imaging equipment and sensing algorithms being used for marine debris reconnaissance, noting the potential for adapting these to detect cetaceans at or near the surface.
- The marine sanctuary program may be able to provide acoustic sensing equipment for use in American Samoa.

Common Name	Scientific Name
Rough-toothed dolphin	***Steno bredanesis***
Risso's dolphin	***Grampus griseus***
Bottlenose dolphin	***Tursiops truncatus***
Pantropical spotted dolphin	***Stenella attenuata***
Spinner dolphin	***Stenella longirostris***
Striped dolphin	***Stenella coeruleoalba***
Fraser's dolphin	***Lagenodelphis hosei***
Melon-headed whale	***Peponocephala electra***
Pygmy killer whale	***Feresa attenuata***
False killer whale	***Pseudorca crassidens***
Killer whale	***Orcinus orca***
Short-finned pilot whale	***Globicephala macrorhynchus***
Blainville's beaked whale	***Mesoplodon densirostris***
Cuvier's beaked whale	***Ziphius cavirostris***
Longman's beaked whale	***Indopacetus pacificus***
Pygmy sperm whale	***Kogia breviceps***
Dwarf sperm whale	***Kogia sima***
Sperm whale	***Physeter macrocephalus***
Blue whale	***Baleanoptera musculus***
Fin whale	***Balaenoptera physalus***
Sei whale	***Balaenoptera borealis***
Minke whale	***Balaenoptera acutorostrata***
Bryde's whale	***Balaenoptera edeni***
Humpback whale	***Megaptera novaeangliae***
North Pacific right whale	***Eubalaena japonica***

Studies of Odontocete Population Size, Population Structure, and Behavior in the Main Hawaiian Islands

by
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Allan D. Ligon
Gregory S. Schorr
Jessica Huggins
Karen K. Martien
Dan R. Salden
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Baird summarized small-boat research on cetaceans around the main Hawaiian Islands over the past 5 years, emphasizing:

- Stock structure (*e.g.*, interchange between islands using photo-identification, genetic analyses of biopsy samples);
- Population assessment (*e.g.*, mark-recapture abundance estimation using photo-identification);
- Behavior and ecology (*e.g.*, dive monitoring with time-depth recorders and VHF radio tags or camera systems, habitat use, trophic ecology using stable isotope analyses of biopsy samples and observations of predation);
- Interactions with people and fisheries (*e.g.*, analyses of photographs of scarring, records of vessels "fishing on" dolphins, observations of "swim-with" activities). Most of the "fishing on" dolphins involves pantropical spotted dolphins, but it happens at least occasionally with other species, including ziphiids.

The study area consists of four discrete segments—Hawai'i, "4-islands," O'ahu, and Kaua'i/Ni'ihau—each with a different ratio of shallow to deep surrounding waters. Relatively little shallow water (0–200 m) is present off Hawai'i while relatively little deep water (> 500 m) is surveyed off Maui/Lanai. Baird's team travels no farther than about 40 km offshore and therefore samples mainly "island-associated" rather than "pelagic" populations. They are limited to working in good weather and sea conditions. The searching and sampling is nonrandom and nonsystematic, with 60–160 km of transect covered on most days. Effort is heavily skewed toward the southern and western sides (lee shores) of the islands. Total effort between 2000 and 2005 covered nearly 28,000 km spanning 10 of the 12 months (no effort in July–August), and 528 sightings of odontocetes were recorded. The total number of genetic samples currently available for Hawaiian odontocetes is approximately 750 for Baird's group and NOAA combined. Photographic catalogs have been compiled for nine species, not including two—spinner and pantropical spotted dolphins—for which substantial numbers of photographs are available.

Photo-identification results for bottlenose dolphins indicate shallow depth distribution, high site fidelity, and no recorded movements of marked individuals among the main islands. Taken together with genetic analyses to date, these results suggest the existence of small, demographically independent populations, each of which may warrant management as a separate stock (Martien et al., 2005). Microsatellite analyses are planned to examine stock structure further. Data and analyses to date also suggest that rough-toothed dolphins, in spite of their typically oceanic distribution, occur in small numbers with strong site fidelity to specific islands in the Hawaiian chain (Webster et al., 2005). Melon-headed whales were the sixth-most frequently encountered odontocetes (see Huggins et al., 2005). They appear to prefer waters deeper than 2000 m, and occur in groups of 300-500 (up to about 800) individuals. Although rarely sighted, pygmy killer whales off the Island of Hawai'i may constitute a very small, isolated population (McSweeney et al., 2005). Preliminary analyses of a 20-year database indicate strong and persistent associations among individuals, suggesting that social affiliations in pygmy killer whales should be investigated in a more focused way. Dwarf and pygmy sperm whales are seen only occasionally and when sighting conditions are excellent (Baird, 2005). Low sighting rates for these two species likely reflect more about their cryptic behavior and the need for ideal conditions to observe them, than they do about actual densities. (False killer whales were covered in a separate talk by Baird; see below).

Baird identified four general areas of research need, as follows:

- More effort off western most main islands (O'ahu, Kaua'i, and Ni'ihau) and off Northwestern Hawaiian Islands

- Survey effort throughout the year

- Long-term effort, particularly focused on rarely sighted species such as the false killer whale, pygmy killer whale, and beaked whales

- Documentation of inshore/offshore movements (*e.g.*, through satellite tracking).

Participants emphasized that more attention should be given to correcting the imbalance between survey effort on the leeward and windward sides of the islands, given how strongly the effort reported by Baird has been biased toward the lee coasts.

Baird noted three planned research initiatives: a 2005 survey off Kaua'i and Ni'ihau, 2005/06 work off Hawai'i, and some VHF and satellite tagging of false killer whales and short-finned pilot whales. Also, he anticipates having some opportunity to use a pole-cam to document head scarring on those two species as a way of evaluating longline interactions.

In discussion, the question was raised as to how the composition of Hawaii's cetacean fauna inferred from sightings data compared to that inferred from strandings (Maldini et al., 2005). Baird noted that there are major differences, notably in the representation of *Kogia* spp., which are relatively common in the stranding records but rarely observed at sea. Also, in Baird's nearshore surveys, striped dolphins are rarely seen, but they are among the most frequently stranded cetaceans in Hawaii. As explained by Maldini et al., (2005), offshore surveys by Barlow (2003) "confirmed that striped dolphins are among the most abundant species in pelagic waters around the main Hawaiian Islands and recorded a frequency of occurrence similar to that predicted by strandings."

Baird reported that in his experience, striped dolphins in Hawaiian nearshore waters show a strong flight/avoidance response to boats, beginning at separation distances of 2-3 km. He also stated that Risso's dolphins, Cuvier's beaked whales, and *Kogia* spp. typically avoid boats in these waters, while other species do not. Some species exhibit between-island differences in their responsiveness. Baird's observations led to a discussion of whether such behavior (i.e., direction and intensity of responses to boat approaches) is conditioned by fishing practices (e.g., shooting or other deterrence measures). The long-established bait-stealing behavior of bottlenose dolphins around the Island of Hawai'i, for example, has probably resulted in retaliatory actions by the fishermen there (e.g., Shallenberger, 1979).

In response to the suggestion that some rough-toothed dolphins may subsist primarily on mahimahi (*Coryphaena* sp.), Baird stated that he had frequently seen them feeding in Hawaiian waters, but never on mahimahi.

Among other suggestions by participants were that Baird and his team make greater effort to sample feces (to evaluate long-term stress, and possibly to determine pregnancy); pay more attention to differences in distribution by sex (including use of biopsy sexing for nonsexually dimorphic species); and integrate into their analyses more consideration for features and oceanographic processes (other than only depth categories) that may be driving cetacean distribution. In response to the last of these points, Baird noted that, in most cases, sample size was a limiting factor for finer-scale analyses of species distribution in relation to features. One interesting observation, however, was that his short-term tag follows of Blainville's beaked whales indicated movement across rather than only along depth contours, suggesting that this species is less associated with features than implied by studies in the Bahamas.

Aerial Surveys of Cetaceans in Hawaii

by
Joseph R. Mobley, Jr.

Mobley summarized 10 years of aerial surveys for cetaceans in Hawaiian waters (1993-2003; see Mobley et al., 2000; 2003). Such surveys have been used to assess distribution and abundance (distance sampling techniques), ground-truth acoustic detections (for locations and species identifications), and investigate reactions to anthropogenic sound.

Mobley began by outlining advantages and disadvantages of aerial surveys as compared to shipboard surveys. Advantages include:

- Quicker coverage of large areas;
- Less expense;
- Less need to be concerned about "flushing" and, for example, double-counting animals that have reacted to the vessel;
- Good optical penetration, assuming low glare and acceptable sea state conditions (i.e., ability to see animals underwater).

Disadvantages include:

- Higher speed means less viewing time and lower probability of detection.
- Species identification for smaller species (e.g., dolphins) is more difficult, especially at high altitudes.
- There is a tendency to fail to recognize multispecies schools as such, and thus to undercount them.
- Safety issues.

In selecting suitable aircraft, bubble windows and/or belly viewing is essential to facilitate maximal viewing ahead of the aircraft and straight down at the track line. A twin-engine Partenavia Observer (P68) has been the aircraft of choice for the Hawaii surveys in recent years. In selecting a survey altitude, there is a trade-off between viewing time and resolving species identities during sightings. For speed, there is a trade-off between efficient coverage and probability of detecting animals. The standard design of the Hawaii surveys has included a target altitude of 230 – 244 m and a ground speed of 185 km/h. Systematic lines have been flown, oriented north-south, spaced at 28-km intervals, extending from shore to 13 km beyond the 1830-m contour, and with the endpoints connected by random lines. Five statewide surveys (main islands only) were completed from 1993 to 2003, limited to the months of February – April.

The list of species from the aerial surveys includes most of those documented in Baird's boat-based surveys (see above), as well as one sighting of fin whales. More than 80% of the sightings in the aerial surveys have been of humpback whales, which are the center of interest for the survey program. Most humpback sightings have been inside the 100-fathom contour, which marks the seaward limit of the Sanctuary. In contrast, odontocetes have been observed in all depth categories. Sperm whales have been seen toward the outer depth limits of the surveys. Estimated densities of humpback whales were increasing at about 7%/yr from 1993 to 2000, but the estimate for 2003 indicated a possible downturn since 2000. A benefit of the aerial surveys, in contrast to Baird's boat-based surveys (see above), is that they provide coverage of the windward sides of the islands. Mobley's distribution maps have not been "corrected" to account for survey conditions, especially sea state, but his abundance estimates have been corrected for sea state by including only data collected in conditions of Beaufort 3 or better.

Mobley summarized a July–November 2002 study that used visual aerial surveillance to "ground-truth" acoustic detections of cetaceans by fixed bottom-mounted hydrophones in the Pacific Missile Range Facility, directly north of the gap between Kaua'i and Ni'ihau (Tiemann et al., in press). Although there was an apparent correlation between the numbers of visual and acoustic detections, the absolute numbers of the latter were, as expected, much higher. Mobley also drew attention to the results of Au et al., (2000), who found a gross correspondence between average

source levels of humpback sounds and the frequency of humpback sightings in Hawaiian waters.

Mobley cited advantages and disadvantages of using visual rather than acoustic detection methods to estimate abundance. On one hand, they currently: (a) are the accepted standard, and (b) provide a more reliable means of determining species identity. On the other hand, they: (a) are limited by various factors affecting visibility (e.g., daylight, diving, sea state); and (b) potential detection distances are generally less than about 5 km. Advantages of acoustic detection methods include: (a) at least when automated, they are not limited by human sensory abilities, fatigue, etc.; and (b) potential detection distances are often much greater. Disadvantages of acoustic detection methods include: (a) although species identification is good for large whales, it is poor for many toothed cetaceans; and (b) although it is possible to estimate relative abundance, estimation of absolute abundance is still in a research and development phase.

Mobley summarized his study of the reactions of humpback whales to the North Pacific Acoustic Laboratory (NPAL, successor to ATOC) sound transmission in 2001–2003 (Mobley, 2005). The monitoring program included aerial surveys all around Kaua'i during the winter season of 2001 while the signal was not being transmitted (control), followed by replicate surveys in 2002 and 2003 that began immediately upon cessation of a 24-hr cycle of transmissions (exposure). No significant between-year differences were found in sighting rates, whale location depths, whale distances from the NPAL source, or whale distances offshore. Three possible interpretations of these results were considered: (a) the whales had habituated to the signal (ATOC began transmissions at Kauai in 1998 and stopped in October 1999); (b) the study had insufficient statistical power to detect any effects; or (3) the effects were short-lived and became undetectable shortly after cessation of transmissions.

Finally, Mobley described his efforts to evaluate the potential for using radar to detect cetaceans at the surface and avoid ship collisions—Project Humpback (in collaboration with D. DeProspo, C. Chinn, L. Sorrell, and M. Deakos). The first phase of this study was conducted in 2003 at the Mahaka Ridge Test Site off northwestern Kaua'i. A visual tracking module situated about 500 ft (152 m) above sea level was used to track humpback whales both visually and with radar. It was determined that radar detection was feasible at distances up to 16 km. The second phase of the study was conducted in the Mediterranean Sea in May-June 2005 (CEDAR Med'05). Shipboard radar and "Big Eyes" binoculars were used to detect fin whales and striped dolphins.

Mobley cited three principal research priorities from his perspective, as follows:

- Continued monitoring of humpback whale population trends, particularly given the apparent downturn in numbers suggested by survey results in 2003;
- Consolidation of the aerial survey data series for odontocetes, which would mean extending the preliminary results of 1993–1998 surveys (Mobley et al., 2000) to include the surveys in 2000 and 2003;
- Further development of acoustic survey methods to at least supplement or complement, and possibly eventually replace, visual survey methods.

Discussion following Mobley's presentation centered on this last research priority and the need for a comprehensive database of cetacean sound types so that acoustic data can be classified to species or at least binned according to appropriate species groups. Barlow drew attention to the work of Julie Oswald, a Ph.D. student at Scripps, who is using two approaches to achieve such classification. She has had 60-70% success attempting to identify seven species from data recorded in the eastern tropical Pacific. Barlow cautioned that, given the great variability exhibited by many delphinids, considerably more development will be needed before the classification of undifferentiated acoustic data can become routine.

Humpback Whales in Hawaii

by
David K. Matilla

Matilla referred to Mobley's aerial survey results (above) demonstrating that humpback whales in Hawaii occur primarily in nearshore waters less than 182 m deep. Other studies have shown that females with calves tend to use shallower water nearer shore than other whales (Smultea, 1994; Ersts and Rosenbaum, 2003).

Again according to Mobley's surveys, abundance of humpbacks in Hawaii appears to have increased at an average rate of about 7% per year from 1993 to 1998, but to have declined over the following 5-year period.

Calves are especially susceptible to vessel strikes. Mothers often dive for 20-30 minutes while the calves surface alone every 3 or 4 minutes. Areas considered to be of particularly high risk of collisions are the passages between Lanai and Maui/Molokai and the near-shore waters of western and southern Molokai, western Maui, and northwestern Hawai'i.

Collision-avoidance ("safe-boating") guidelines issued by the National Marine Sanctuaries consist of the following:

- Keep a sharp lookout—post a dedicated lookout from November through May; look for "blows" (puffs of steam), dorsal fins, tails, etc.
- Never leave the helm—be in position to safely change course and/or speed on short notice.
- Watch your speed—slower speeds give vessel operators and whales more time to react.
- Keep your distance—once whales are sighted, stay at least 100 yards away.
- Stop immediately if within 100 yards of a humpback whale—use prudent seamanship in deciding either to move away or to wait for the whale(s) to move away.

Humpback Whales in Hawaii

by
Louis M. Herman
Adam A. Pack
and
Alison S. Craig

Herman and his colleagues have been studying the behavior and social dynamics of humpback whales in Hawaii for nearly 30 years. Based on photo-identification matches, the animals that winter in Hawaiian waters migrate mainly to summer feeding grounds in southeastern Alaska; some go elsewhere in the Gulf of Alaska or to British Columbia or central California (Calambokidis et al., 2001). Whales photo-identified in Hawaii have occasionally been observed in other wintering grounds in different years—e.g., between Hawaii and Mexico and between Hawaii and Japan. All such individuals thus far have been males. "Switching" between island areas within the Hawaiian wintering grounds also involves mostly males. Overall, there appear to be three largely separate populations in the North Pacific based on their use of different wintering grounds in Japan, Hawaii, and Mexico.

The first animals to arrive on the Hawaiian wintering grounds each year are late-lactation females along with juveniles (Craig et al., 2003). Females with no calf arrive and leave earlier than females with a calf. Herman stated that the order of arrival and departure of the different age, sex, and reproductive classes in Hawaii was consistent with Dawbin's data from the Southern Hemisphere (e.g., see Dawbin 1966:159-160). Estimates of "residency" time on the wintering grounds in Hawaii also suggest that females without calves spend relatively short periods there, on average about 2 weeks, compared with up to 4 weeks for juveniles, 6 weeks for females with calves, and 11 weeks for males (Craig et al., 2003).

Individuals have been resighted in Hawaii over intervals of up to 28 years. Sexual maturity is attained at an average age of about 5 years. The fetal sex ratio is not different from 1:1. The observed male:female ratio of whales observed in Hawaii is 1.86:1 (Craig and Herman, 1997). Pod and individual animal density, number of calves, and calves/whale/year are all higher off Maui than off Hawai'i. Also, a female when with a calf is more likely to be seen off Maui than off Hawai'i (Craig and Herman, 2000). The peak density of whales occurs in February and March off Maui, earlier in the season off Hawai'i.

The function of humpback whale song continues to be a subject of investigation and speculation. Although it is known that only males sing, it remains unclear whether the main function of singing relates to lekking, spacing, advertising, synchronizing ovulation, or something else. Singers are spread out spatially. All males probably sing regardless of their maturity status. They can sing while acting as "escorts." Song does not appear to attract females. However, males are observed to join other males and often form what are called competitive groups (see Craig et al., 2002). The so-called principal escort is generally the largest individual in a competitive group, so size appears to confer an advantage of some kind (Spitz et al. 2002). As a female gets larger, she tends to attract a larger number of male escorts. Males prefer to escort females that do not have calves in attendance. As females without calves become rarer late in the season on the wintering grounds, this preference on the part of males becomes less pronounced.

Herman recommended the following research directions:

- More investigation of demography in relation to habitat use off Oahu and Kauai;
- Further analyses of interisland movements (e.g., using data from the SPLASH program);
- Social dynamics;
- Improved understanding of the mating system of humpback whales so that it, i.e., the system as a whole, gets needed protection;
- Determination of when and where births occur;

- Investigation of non-song vocalizations;
- Additional application of crittercams with humpback whales (see below);
- Paternity studies to determine whether principal escorts are, in fact, fathers of the next season's calves.

In discussion, Matilla challenged Herman's conclusion that the male-biased sex ratio of humpback whales in Hawaiian waters in winter is consistent with the sex ratios of whales taken in shore fisheries and sampled in biopsy programs in the Southern Hemisphere and therefore is typical of the species. This question merits critical evaluation with reference to the published evidence—e.g., Dawbin (1966), Brown and Corkeron (1995), Brown et al. (1995), and Mate et al. (1998). One possible explanation for the relatively short residence times of females on the wintering grounds is that they are seeking to avoid harassment by courting males. Matilla does not think the underrepresentation of females on the wintering grounds means that a relatively high proportion of females remains in high latitudes and does not migrate all the way to Hawaii and other "breeding" grounds. Rather, he thinks it only means that females have shorter residency times on these grounds. He noted that few females had been observed to overwinter in feeding areas.

As a supplement to his main presentation, Herman summarized five deployments of crittercams on humpback whales off Maui in January–February 2005. The main objective, in addition to testing feasibility, was to obtain new insights on the humpback's mating system. Herman noted that mating by humpbacks has never been directly observed. Both rear-facing and forward-facing lenses were placed on individuals identified as "principal escorts." Among other things, it appeared that the female was actively trying to stay near the principal escort. In future deployments, Herman hopes to be able to place the crittercam on the focal female in a courting group.

Abundance and Stock Structure of Cetaceans in the Pacific Islands Region

by
Karin A. Forney
and Jay Barlow

Forney reviewed the stock assessment framework under the Marine Mammal Protection Act, which requires calculation of a Potential Biological Removal (PBR) level for each stock and an estimate of human-caused mortality for comparison against it (Wade and Angliss, 1997). Key data needs are information on stock structure, an abundance estimate, and an estimate of nonnatural mortality. If human-caused mortality exceeds the PBR, a stock is designated as strategic. Nineteen cetacean species in Hawaii were covered in 1995 stock assessment reports, but the reports included many data gaps and there were no estimates of abundance, mortality, or PBR for most species. Since that time, the Southwest Fisheries Science Center has provided small-scale support for projects in Hawaii to begin filling some of the data gaps (e.g., see presentations by Mobley and Baird). A major update of the stock assessment reports was published in 2000, incorporating 1994-1998 data on cetacean interactions with longlines (Kleiber, 1999) and preliminary data on odontocete abundance from aerial surveys between 1993 and 1998 (Mobley et al., 2000). False killer whales in Hawaii were identified as a strategic stock because of their estimated incidental mortality in the longline fishery.

Relevant research since 2000 has included:

- A large-scale ship survey in 2002 —Hawaiian Island Cetacean and Ecosystem Assessment Survey (HICEAS; Barlow et al., 2004);
- Further analyses of longline-caused mortality, by EEZ (Forney, 2004; Forney and Kobayashi, in preparation);
- Genetic studies of stock structure of false killer whales, short-finned pilot whales, and bottlenose dolphins, led by Susan Chivers and Karen Martien;
- Continued nearshore surveys and collection of photo-identification data (e.g., by Baird and Mobley).

From 1986 to 1996 the SWFSC conducted 200,000 km of summer/fall ship surveys, covering an area of more than 25,000,000 km^2 along the U.S. west coast and offshore throughout the Eastern Tropical Pacific (ETP). The 2002 HICEAS followed a uniform systematic design, with the intention of covering the entire Hawaiian Islands EEZ using standard visual line transect methods supplemented by a towed acoustic array. Estimates of group size were calibrated using multiple independent observers, resulting in an average correction factor of 0.86. Estimates of g(0) were obtained empirically for non-cryptic or non-deep-diving species (delphinids and large baleen whales) and by modeling for cryptic or deep-diving species (sperm whale, Cuvier's beaked whale, *Mesoplodon* spp., and *Kogia* spp.). Effort with sea state 0–6, which was used for density estimation for most species, totaled 3550 km in the Main Island Stratum and 13,500 km in the Outer EEZ Stratum. For ziphiids and kogiids, only effort with sea state 0–2 was used, totaling 488 and 900 km, respectively.

The sperm whale was the most frequently sighted large cetacean. Bryde's whales were observed only in the Northwestern Hawaiian Islands; their acoustic pattern differed from those of Bryde's whales recorded in the eastern tropical Pacific. The striped dolphin was the most frequently sighted small cetacean. Fraser's dolphin was "new" to the list of species recently observed in Hawaiian waters. The low number of sightings of false killer whales was a major disappointment, but appears to reflect the relative rarity of this species in Hawaiian waters.

There were few sightings for most species, little survey coverage took place in "calm" conditions, and the geographic coverage in "calm" conditions was poor. Because of the small number of sightings, effective strip widths needed to be estimated incorporating data from ETP surveys. Although the diversity of species observed was high (including minke, sei, and Longman's beaked

whales), densities were generally low compared to many other areas (e.g., North American continental shelf and slope waters, ETP).

The lack of dedicated survey effort in the EEZs of Palmyra, Johnston Atoll, Jarvis Island, Howland and Baker Islands, and American Samoa represents a major research gap. Not only do those areas lack abundance estimates, but they also lack studies of stock structure and by-catch.

Two patterns are emerging from genetic analyses of stock structure in Hawaiian odontocetes. Preliminary results point, on one hand, to localized, island-specific stocks of bottlenose dolphins, while on the other hand, there appear to be Hawaiian stocks of short-finned pilot whales and false killer whales that are very distinctive from animals in the ETP. With regard to false killer whales, there is reason for concern that animals are being taken incidentally on longlines from populations that have not been identified as such and that have not yet been surveyed, e.g., around Palmyra Atoll.

In summary, dedicated broad-scale surveys and analyses of biopsy and photo-identification data have shown that:

- Densities in Hawaiian waters are low for most cetacean species.
- Abundance estimates (usually with low precision) are available for almost all of the 24 species observed in the 2002 survey (none for blue and minke whales).
- Four "new" species have been added to or confirmed for the Hawaiian checklist (Fraser's dolphin, Longman's beaked whale, sei whale, and common minke whale).
- Genetic analyses indicate distinct Hawaiian populations of pilot and false killer whales.
- There is evidence of between-island population structure in spinner dolphins, bottlenose dolphins, and some others.
- The false killer whale continues to be the only strategic stock.
- Forney and Barlow identified the following data gaps for the region:
- Abundance estimates and stock-specific information for the EEZs of other islands;
- Better information on cetacean interactions with longline fisheries to facilitate mitigation;
- Better information on cetacean interactions with other fisheries, including nearshore and recreational fisheries;
- Improved understanding of stock structure, particularly with regard to geographical boundaries of stocks and determining which stocks are affected by a given source of human-caused mortality and injury.

In discussion, participants questioned whether other stocks around Hawaii, in addition to false killer whales, were likely to qualify as strategic. Barlow stated that spinner dolphins and bottlenose dolphins are of most concern and that assessment of their status could change as more is learned about stock structure and interactions with human activities. During a brief discussion of killer whales, Barlow pointed out that those observed in Hawaiian waters bore wounds from cookie-cutter shark bites – something generally not seen on killer whales in the eastern North Pacific. Baird reported that genetic analyses of biopsies from Hawaiian killer whales revealed one mtDNA haplotype not yet reported in studies of killer whales elsewhere (Baird at al., in press).

The HICEAS results apply only to the late summer and fall season (August-November). A survey in winter and spring might produce a different picture, particularly in regard to abundance of the migratory mysticetes.

Humpback Whales in American Samoa

by David K. Matilla

Matilla summarized work based at the Fagatele Bay National Marine Sanctuary on the island of Tutuila. Humpback whales were common all around the archipelago in the 2003 and 2004 field seasons (September-October, or austral late winter to early spring), and a photographic catalog of 42 individually identified humpback whales has been assembled. Additional work is planned for September-October 2005. Matches have been made between American Samoa and three other wintering areas of Southern Hemisphere humpbacks: Cook Islands, French Polynesia, and Tonga. Behavior of the whales is typical of the repertoire observed in other winter mating and calving grounds around the world. The animals that winter near American Samoa migrate to feeding grounds in the Antarctic during the non-winter months. Occurrence of these whales in the EEZ of American Samoa links U.S. interests to the ongoing controversy over Japan's stated plan to begin "scientific" whaling on Southern Hemisphere humpback whales in the near future. It also provides a rationale for U.S. support for and participation in the South Pacific Whale Research Consortium.

In discussion, Herman called attention to the significance of the Townsend charts of historical whale distribution. He stressed that those charts provide a record of where humpbacks were found by American open-boat whalers during the 19th century and therefore indicate areas that either are occupied, or should become reoccupied, by recovering humpback whale populations.

Cetaceans in American Samoa

by William F. Perrin

This presentation was derived from a contract report submitted by Louella Dolar to the Department of Marine and Wildlife Resources, American Samoa Government. Marine mammal research in American Samoa is in its infancy. Only two species of mysticetes are known to occur there – the humpback whale and a species of minke whale (unclear whether this is the common minke, *Balaenoptera acutorostrata*, or the Antarctic minke, *B. bonaerensis*). It is reasonable to expect at least one species of Bryde's whale to be present as well (*B. edeni* and/or *B. brydei*). The odontocete fauna is approximately as one would expect of any tropical oceanic island group. So far, nine species have been documented on the basis of either sightings or strandings: sperm whale, short-finned pilot whale, killer whale, common bottlenose dolphin, pantropical spotted dolphin, spinner dolphin, Cuvier's beaked whale, rough-toothed dolphin, and false killer whale. Seven additional odontocete species would be expected to be present at least occasionally or perhaps seasonally: dwarf and pygmy sperm whales, melon-headed whale, Risso's dolphin, striped dolphin, Fraser's dolphin, and one or both species of common dolphins.

The following activities were recommended:

- Develop and augment local cetacean expertise.
- Continue the inventory of American Samoa's cetacean fauna and seek to obtain population estimates. With respect to the inventory, it was specifically recommended that interviews be conducted with local people (following the Philippines model). Among other things, such an approach can locate specimens and photographs and provide information on fishery interactions and other threat factors.
- Investigate cetacean mortality in fishing gear, always with the ultimate goal of obtaining quantitative data, by species and by fishery.
- Identify cetacean stocks and the range of distribution for each.
- Establish a stranding reporting and response network, which may involve the production and distribution of posters and other materials, holding workshops and

seminars, and providing dissection equipment, preservatives, etc.

- Make efforts to raise conservation awareness.

- Develop or strengthen links with other South Pacific countries and territories and with other relevant programs and agencies. For example, the South Pacific Regional Environment Program (SPREP) is pursuing a regional marine mammal initiative in collaboration with the Convention on Migratory Species (CMS).

In discussion, Johnston called attention to the Stock Assessment Improvement program and a recent proposal by the PIFSC to gather background information regarding cetacean species assemblages, relative commonness or rarity of individual species, and interactions with humans and fisheries in inhabited portions of the US Pacific Islands Region. This would involve inexpensive reconnaissance efforts to survey local people and institutions. In addition to acquiring local knowledge, the proposed project was seen as an opportunity to establish contacts with key individuals and institutions and obtain information on locally available assets (e.g., boats, aircraft) and expertise. Pre-visit planning would involve identifying key contacts and preparing a general survey, with questions designed to learn which species are present, how often they are seen, and any known interactions. Once on site, interviews would be conducted with local government officials, resource managers, fishermen, and others who spend time in the marine environment (e.g., divers, tour boat operators). Museums or other specimen collections would also be visited to examine cetacean material. Finally, Johnston noted the value of more extensive consultations with local people in Hawaii, possibly in collaboration with local or regional cultural historians

It was also noted that the longline fishery observer program, soon to be implemented in American Samoa, has the potential to provide valuable sightings data and information on fishery interactions. Forney emphasized the importance of having those observers record data that can be used to estimate effort.

Whale and Dolphin Interactions: The Guam Experience

by Thomas Flores, Jr.

Although some information on cetaceans in Guam is available in the literature (e.g., Donaldson, 1983; Eldridge, 1991; Kami and Lujan, 1976; Kami and Hosmer, 1982; Reeves et al., 1999), no research program exists there. Fishermen regularly report strandings to authorities, and in this way the presence of numerous species has been documented—e.g., sperm, dwarf sperm, and pygmy sperm whales, melon-headed whales, short-finned pilot whale, killer whale, and spinner and striped dolphins (reportedly, also Cuvier's beaked whale and a species of common dolphin). In addition, opportunistic sightings have been reported of sei, Bryde's, and humpback whales, killer whales, and Risso's dolphins. Spinner dolphins occur in numerous embayments and they have become popular targets of dolphin-watching tourism. Approximately ten operations are involved; they operate year-round and focus on spinner dolphins and pilot whales.

Although the residents of Guam have no cultural tradition of whaling or dolphin hunting, American and French commercial whalers came there during the 19th century. The island was used for provisioning, rest and relaxation, and trade; also, some Chamoru men joined whaling crews. Among the existing or emerging management problems identified by Flores were the following:

- When whales strand in shallow coastal waters, people who wade out to observe them (or obtain meat) are at risk of shark attack.
- The jawbones and teeth of stranded cetaceans are often collected as souvenirs.
- On one occasion when a pod of spinner dolphins was attacked by sharks in Cocos Lagoon, people attempted to rescue a juvenile dolphin by removing it from the water and requesting that it be cared for and rehabilitated by the Division of Aquatic and Wildlife Resources (it died before help arrived).
- Dolphin-watching operators approach the animals closely and sometimes even herd or trap

them, leading to concerns about harassment.

- People have been known to jump into the water with a pod of sperm whales to film and photograph the animals (this happened in 2002).

- Most strandings are dealt with by local people who simply either bury the carcass or push or tow it into deep water. In response to a question, Flores stated that he had no evidence that would link strandings to fishing activity (e.g., net marks on carcasses).

- A foreign longliner boarded by the Coast Guard in November 2003 had a ginkgo-toothed beaked whale in its freezer. The crew claimed that it was destined for the Japanese market. The whale reportedly had been caught in waters of the Federated States of Micronesia. It was unclear how it had been taken, i.e., whether on a longline as bycatch or by harpooning. Perrin pointed out that Taiwanese fishing vessels (both longliners and purse seiners) operate illegally throughout much of the Indo-Pacific.

Because of the geographic proximity of Guam and the Northern Mariana, cetacean research programs in the two areas should be closely linked and coordinated. Flores noted that the current situation in the Northern Mariana is generally similar to that in Guam, i.e., there is no well-organized and sustained program of cetacean research, monitoring, and conservation at present. All of the recommended activities listed above for American Samoa apply with equal force to Guam and the Northern Mariana. Given the current interest and capabilities on Guam, it should be possible to start obtaining tissue samples for genetic (and other) analyses from strandings right away, on an opportunistic basis. As in the case of American Samoa, this will require that local people are provided with the requisite equipment, preservatives, etc., and they should also be involved in any regional training workshops and other capacity-building initiatives.

Current Laboratory Basic Research: Hearing and Echolocation

by

Paul Nachtigall

The essential thrust of this presentation was to encourage NMFS to keep basic scientific research, including experimentation using cetaceans held in laboratories, viable at the same time that the agency pursues its obligatory applied (i.e., problem-driven) research mission on wild populations. Experiments conducted in controlled conditions can be used for extrapolations to field situations. Nachtigall stressed that peer-reviewed publication should remain the backbone of a credible research agenda, allowing open criticism of ongoing work and providing researchers with the opportunity to counter allegations that their results might be tainted by their sources of funding.

The University of Hawaii's Institute of Marine Biology uses two facilities for its marine mammal research program. Captive animal enclosures at Coconut Island currently house two captive-born Atlantic bottlenose dolphins and a single false killer whale. The Kaneohe Marine Base support facility provides a wet lab, a complete veterinary hospital, walk-in freezers, temporary holding tanks, a fenced-off holding bay, and other necessities for the institute's stranding response work.

The focus of the institute's research program is on two sensory processes – hearing and echolocation – both of which are relevant to major issues faced by NMFS in recent years, e.g., the effects of underwater sound on cetaceans and the problem of cetacean interactions with longline fishing. Initial tests of hearing ability (i.e., determinations of hearing thresholds) require a laboratory setting where trained behavior protocols or Auditory Evoked Potential Procedures (AEPP) can be applied. To obtain a behavioral audiogram, a sound is produced and the animal is trained to respond when it hears the signal (Nachtigall et al., 2000). AEPPs, in contrast, measure the animal's brainwave responses to sounds and they do not require the same level of animal training as behavioral audiograms (Nachtigall and Supin, 2004). They are also faster and have the potential to be used to test the hearing of animals too large to be kept in an enclosure (e.g., stranded sperm whale calves). The two approaches – behavioral audiograms and AEPPs – have been compared in studies of a false killer whale (Yuen et al., in press). Results from both techniques were reliable and repeatable. However, the behavioral audiograms were consistently more sensitive (i.e., yielded lower response thresholds) than the AEP audiograms.

Most odontocetes whose hearing has been measured hear very well at high frequencies. No mysticete's hearing has yet been tested experimentally, but this may be feasible in the near future using AEPPs. Audiograms are currently available for only 11 of some 85 cetacean species.

In addition to their use in measuring hearing thresholds, AEPPs can be used for diagnostic purposes, e.g., to assess whether a live-stranded animal's hearing has been compromised by exposure to underwater sound. For example, Nachtigall et al. (2004a) compared the hearing thresholds of a young Risso's dolphin that stranded in Portugal to those of an old Risso's dolphin from Hawaii and concluded, given the young animal's relatively good sensitivity at very high frequencies, that damaged hearing

as a result of sound exposure had not been a causal factor in its stranding.

Given that acoustic intensity levels are increasing, and expected to continue increasing, in the world's oceans, there is an urgent need to be able to measure the effects of loud sounds on cetaceans. Any effort to regulate sound will have to be supported by scientific evidence of effects, according to sound characteristics (e.g., intensity, frequency, and duration of exposure). One approach for obtaining such evidence is the use of experimental sound exposure to elicit a temporary threshold shift (TTS, the "rock concert effect"; see Nachtigall et al., 2004b).

Because of the demonstrated odontocete echolocation capability to discriminate objects buried more than 2 feet into mud, and the false killer whale's ability to tell the difference between cylinders with wall thicknesses only .003 inches apart, Nachtigall and his colleagues have also been investigating the basic acoustic processes of odontocete echolocation using, for example, a Phantom Echo Generator (PEG) (Aubauer et al., 2000, 2004; Supin et al., 2003). Hearing (of both the outgoing signal and the echo) is measured directly (using AEPPs) while the animal is echolocating. Average AEPs to outgoing clicks and returning echoes are measured for targets at varying distances (Supin et al., 2004, in press). False killer whales appear to possess an automatic gain control mechanism for determining how well they hear echoes while echolocating. This indicates that the echolocation process involves a sophisticated interplay between how an animal hears the outgoing sound and the returning echo from a target.

Cetacean Acoustics: Passive and Active Studies in Hawaii

by Whitlow Au and M.O. Lammers

Au's group at the Hawaii Institute of Marine Biology, University of Hawaii, have been studying the behavioral ecology of spinner dolphins and humpback whales around Hawaii, using differences in phonation as markers. There are significant differences in inter-individual distances of dolphins using whistles and dolphins using burst pulses. There are also relatively small (< 25%) differences in acoustic repertoires and patterns between groups of spinner dolphins at both micro- and macrogeographic scales. Surprisingly larger differences have been documented between the whistle patterns of dolphins off the same island, such as the Waianae coast and the south shore of Oahu. The term "whistle specific subgroup" was coined to reflect these differences.

Spinner dolphins prey on lanternfish and other micronekton of the mesopelagic boundary community (MBC), which is similar to the deep scattering layer (DSL). The MBC was found to migrate not only vertically upward beginning at dusk, but also toward shore until about midnight. The organisms then reverse the migration back toward deeper offshore waters. The hypothesis of Norris and others is that spinners leave their coastal and inshore resting sites at dusk and forage offshore at night, when the MBC migrates upward in the water column. Au's findings, using echo-sounders and multibeam sonars to track dolphins and the MBC, indicate that the dolphins go out and meet the mesopelagic boundary (a high-energy region) as it moves toward shore and then stay with it as it moves toward and away from shore through the night. This allows the dolphins to maximize their foraging opportunities. They appear to forage in a highly coordinated, cooperative fashion, and to spend approximately 9-11 hours per night feeding intensively.

Kim Andrews, one of Au's graduate students, has been analyzing genetic population structure of spinner dolphins throughout the Hawaiian Archipelago. She has analyzed samples from all the main islands and the Northwestern Hawaiian Islands. Preliminary findings indicate that the animals in the Northwestern Hawaiian Islands belong to a single population, while multiple populations occur in the main islands.

With regard to humpback whales, Au's work suggests that current levels of boat noise in Hawaiian waters do not pose a difficulty (e.g., masking) for chorusing whales. During the peak season, humpback sounds dominate the underwater acoustic environment and more singing occurs at night than in the daytime (Au et al., 2000). Source levels of humpback sounds can be as high as 182dB, and harmonics in their sounds can reach 22-23kHz. Au suggested that listening via acoustic moorings would be an inexpensive way of estimating relative densities of singers throughout the Hawaiian chain and of tracking the arrival and departure of singers, both temporally and spatially.

In discussion, participants explored the implications of the genetic and acoustic evidence of multiple stocks of spinner dolphins in the Hawaiian Archipelago. It was suggested that integration with photo-identification data and with previous observational studies (cf. Norris et al. 1994) would be useful. Also, several participants expressed particular interest in the data and calculations (e.g., species and numbers of prey, based on stomach contents of one stranded individual) underlying Au's assertion that Hawaiian spinner dolphins require a nightly 9-11 hr foraging period to meet their energy requirements. This has considerable relevance to the management issues surrounding the dolphins' daytime need for undisturbed rest in bays and coves (see later).

Long-term Cetacean Acoustic Monitoring

by
John Hildebrand
Sean Wiggins
Erin Oleson
Melissa Soldevilla
John Calambokidis
Marie Roch
Mark McDonald

Visual and acoustic methods for surveying cetaceans are complementary. Visual methods depend on the animals' need to surface to breathe, while acoustic methods depend on their use of sound (which is variable) to communicate, navigate, and locate prey. Thus, visual surveys are limited by the ability of observers to see the animals at the surface, while acoustic surveys are limited by the ability of listening equipment to detect the animals' sounds.

According to Hildebrand, the advantages of acoustic monitoring include (see table below for comparisons):

- Acoustic instruments can monitor continuously for long periods of time.
- Acoustic instruments are low-cost (little ship time is required).
- Instruments can be placed in inaccessible regions.
- Detected calls can be used to help define seasonality, stock structure, and relative abundance.

The study by Thompson and Friedl (1982) was groundbreaking as it demonstrated the value of remote, passive acoustic monitoring for the presence of cetaceans in a poorly surveyed area. Two hydrophones north of Oahu recorded underwater sounds between December 1978 and April 1981. At least one kind of whale sound was recorded on 459 of 578 days. These sounds included what the authors described as (1) humpback vocalizations, (2) fin whale short pulses, (3) blue whale long pulses, (4) sperm whale clicks, (5) pilot whale thumps, and (6) the "boing" sound (now known to be made by common minke whales, per Barlow and Rankin). In response to a question, Hildebrand noted that the whales making these sounds could have been as much as 100 km away from the hydrophones, and Au pointed out that Hawaii is in the SOFAR axis so some of the sounds may have come from even farther away.

Acoustic Recording Packages (ARPs) have been used fairly extensively to monitor the sounds of baleen whales in the eastern North Pacific. One unit deployed south of Hawaii to record earthquakes incidentally recorded sounds of humpback, fin, and blue whales as well (Wiggins, 2003). In an effort to learn more about the behavioral context of calls and how much of the time whales are vocalizing, Hildebrand and his colleagues have used acoustic recording tags (pole application, suction-cup attachment) on blue whales in the Southern California Bight. They have also analyzed

Acoustic	Visual
Monitors submerged animals	Monitors surfacing animals
Continuous temporal coverage	Poor temporal coverage
Daylight and weather independent	Daylight and weather dependent
Heat conducted from fixed sites	Heat conducted from moving platform
Best applied to a small locale	Best applied to large region
Poor understanding of how to estimate population parameters	Good understanding of how to estimate population parameters
Good seasonal resolution	Poor seasonal resolution

stability and change in blue whale song patterns in different parts of the North Pacific and the global biogeography of blue whale songs (McDonald et al., in press). One of the more interesting (and provocative) findings from these studies is a clear downshift in frequency of blue whale songs over time since the 1960s, which Hildebrand hypothesizes could be related to the species' recovery from depletion by whaling.

Another area of research and development by Hildebrand's group at the Scripps Institution has involved the use of FLIP, a stable offshore work platform, in experiments to calibrate fin whale call counts to whale densities. Initial comparative analyses indicated (a) little overlap between whales seen and whales heard, (b) higher numbers of calls detected (acoustically) than sightings made (visually), (c) calling whales were generally judged to be traveling, and (d) visually detected whales were usually judged to be feeding.

In comparison to large whales, the small and medium-sized odontocetes present a greater challenge to current acoustic monitoring and assessment capabilities (see Oswald et al., 2003). Rapid technological advances offer the potential for acquiring, storing, managing, and analyzing large data sets over long time scales. High-frequency sensors can be bottom-mounted to record the whistles, clicks, and burst pulses of the smaller odontocetes. However, the resultant large data sets containing highly variable calls require automatic detection and classification algorithms. A graduate student in Hildebrand's lab is attempting to develop this capability using a technique adapted from human speech recognition systems, applied to the clicks and whistles from five dolphin species in southern California. In discussion, Johnston noted that he was planning test deployment of a High-frequency Acoustic Recording Package (HARP) at Cross Seamount, directly south of Oahu, an area of intense longlining activity and presumably large concentrations of oceanic odontocetes. Analysis of data from this deployment (and others) would be facilitated by an automated detection and classification system such as that being developed by Hildebrand's group.

Finally, Hildebrand and his colleagues are attempting to address a number of questions related to the effects of noise on cetaceans. For example, how do the animals change their own sounds as a function of background noise? What proportion of whale calls is missed, whether by conspecifics or by humans attempting to monitor the animals with listening devices, because of background noise?

In summary, there is a need for improvements in the following:

- Methods of call detection and classification;
- Understanding relationships between acoustic and visual techniques;
- Understanding the behavioral context of calling;
- Using acoustic data to define stock structure;
- Understanding the effects of noise on cetaceans;
- Understanding long-term trends in call characteristics.

Acoustic Monitoring of Cetacean Vocalizations and Other Sounds at Cross Seamount

by
Jeffrey Polovina and Dave Johnston

Seamounts are common in the Pacific Islands Region, and they are known to have important physical and biological effects. Physically, seamounts increase local primary productivity and aggregate secondary productivity through a number of processes: increased turbulence and mixing, interruption in the flow patterns of tidal and greater-frequency currents, and their vertical structure that can extend to just below the sea surface. Biologically, they enhance the prey field in near-surface waters by advecting the deep scattering layer over the summit at night and then trapping organisms there as the scattering layer descends with growing daylight in the early morning. A High-frequency Acoustic Recording Package (HARP) will be deployed on Cross Seamount to begin exploring its significance to cetaceans, and also, by extension, the potential importance of other seamounts.

Photo-identification of Cetaceans and Collaborative Catalogs: Experience from the Mid-Atlantic Bottlenose Dolphin Central Catalog (MABDC)

by
Kim Urian

A large die-off of coastal bottlenose dolphins along the east coast of the United States in 1987-88, together with improved documentation of fishery by-catch levels, resulted in 1993 in the listing of the coastal migratory population there as “depleted” under the Marine Mammal Protection Act. NMFS has a legal responsibility to determine stock structure and, for each stock, estimate abundance and calculate a Potential Biological Removal (PBR) level. Estimated human-caused mortality is then compared to the PBR level as a tool to manage fishery by-catch.

Specifically to address the problem of stock structure, the Mid-Atlantic Bottlenose Dolphin Central Catalog (MABDC) was established in 1997. The objectives were to assess movement and residency patterns and to facilitate information exchange among researchers who contributed to the catalog. Contributors and catalog managers and users have met in a series of workshops (e.g., Urian and Wells, 1996).

The MABDC is a component of an overall strategy on the part of the Southeast Fisheries Science Center (SEFSC) to use multiple methods to assess stock structure including, in addition to photo-identification, genetics, telemetry, stable isotope ratios, life history, and morphometrics (Hohn, 1997). The MABDC was modeled after well-established collaborative catalogs that use individual identification to monitor wide-ranging populations—the Sirenia Project (West Indian manatees), the North Atlantic Humpback Whale Catalog, and the North Atlantic Right Whale Consortium. A consent form must be signed each time an image or data set is contributed (see Urian et al., 1999). The intention is to standardize methods but allow researchers to maintain their autonomy.

Contributed images are assigned a quality ranking (excellent, average, poor) and a ranking that reflects “distinctiveness” of the dorsal fin (very distinctive, moderately marked, and not marked). A computer-assisted matching program (Finscan; Hillman et al., 2003) is used to sort dorsal fins into separate catalogs for each site, compare each dolphin to every other dolphin, and assign match numbers to dolphins matched to more than one site. Verification procedures are shown below.

From 461 identified dolphins based on images from six contributors in May 1998, the MABDC has grown to include 4,014 individual dolphins documented from photographs contributed by 26 different individuals or teams, ranging between Cape May, New Jersey, and Indian River, Florida. As of 2002, the stock structure diagnosis consisted of seven summer distribution management units and five or six winter distribution management units (Waring et al., 2002).

Urian summarized the following lessons learned from the MABDC experience:

- Understanding the biology of cetaceans with large ranges requires a collaborative approach.
- Photo-identification is a powerful tool that allows the integration of data over large areas and long time scales.
- A photo-identification catalog helps managers see the big picture and allows contributors to learn a great deal more about the movements of individual animals than they would working in isolation.
- The method requires collaboration and encourages cooperation among researchers.
- The importance of face-to-face discussions and formal agreements between contributors, funding agencies, and managers should not be underestimated.

Future plans for the MABDC include publication of a synthesis paper, provisionally titled "A collaborative approach using photo-identification techniques to define population units of bottlenose dolphins along the U.S. east coast"; synoptic surveys to refine understanding of winter stock structure in North Carolina coastal waters; and development of a web-based version of the catalog to browse, match, and identify dolphins.

It was agreed during the discussion following Urian's presentation that a similar approach should be pursued with bottlenose and spinner dolphins in Hawaii.

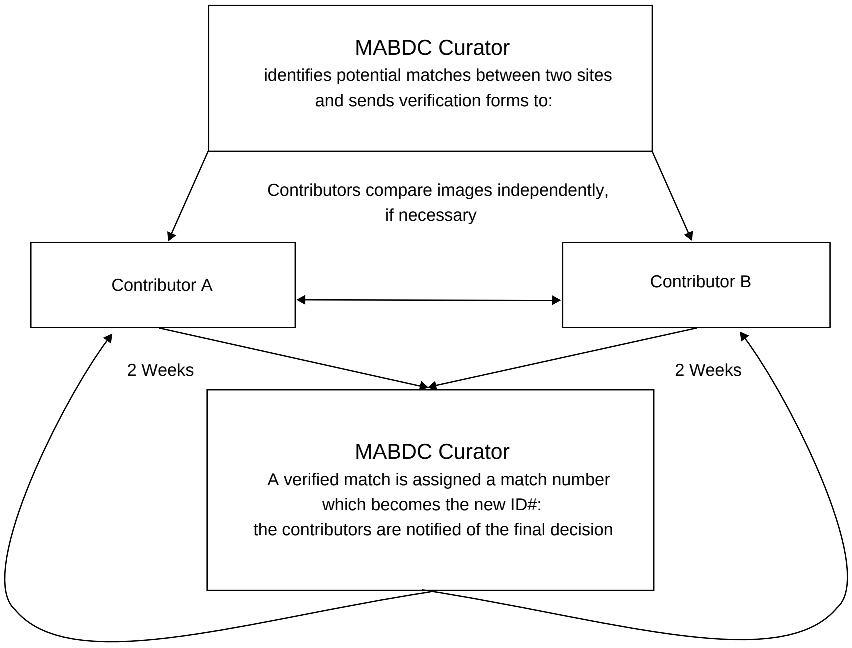

Photo-identification of Cetaceans and Collaborative Catalogs: The SPLASH Experience

by David Matilla and Jay Barlow

Matilla reported that the humpback whale fluke archives for the North Pacific, based at the National Marine Mammal Laboratory in Seattle, are currently in a holding state as the system has been overwhelmed by contributed images. Over the years, collaborative publications from the catalog have appeared (e.g., Mizroch et al., 2004), but largely as a result of individual initiatives rather than a well-supported, carefully planned and managed program. The Structure of Populations, Levels of Abundance and Status of Humpbacks program (SPLASH program)—a collaboration among NOAA Fisheries, NOAA Sanctuaries, the National Park Service, the Canadian Department of Fisheries and Oceans, the Government of Mexico, universities, and NGOs—is expected to provide a much more extensive and authoritative view of humpback population status in the North Pacific than has been available to date. The stated objectives are to:

- Improve understanding of population structure (genetic and demographic), migratory movements, current abundance and trends, population parameters and human impacts;
- Identify areas of critical action, i.e., areas where local populations of humpback whales are very small and not recovering or are heavily affected by human activities (e.g., entanglement, ship strikes, pollution);
- Foster international collaboration and cooperation (some 130 researchers from 10 countries are currently involved in humpback research in the North Pacific);
- Leave a legacy of data and archived tissue.

The plan calls for standardized sampling in three winter and two summer seasons, 2003–2006. Among the priorities for data analysis are to determine the sex of each sampled individual, study genetic structure and gene flow, and conduct hormone (e.g., for indicators of pregnancy), toxicology, and feeding studies. Tissue samples are being processed for safe and accessible long-term storage. In addition to coordination of existing efforts, there is a need to expand sampling to cover unsampled or under-sampled habitats.

Cascadia Research Collective has a contract to curate the photographs. Web access is anticipated, with appropriate protections of contributor rights, perhaps following as a model the Antarctic humpback whale catalog curated by College of the Atlantic. Publication plans are organized around specific program goals, including analyses of overall population structure and size, population estimates for subunits, migratory movements, demographic parameters, and human impacts.

Matilla concluded his presentation by identifying the following benefits of such collaborative projects:

- Data collection, error checking, and other protocols become standardized.
- Analyses are completed that would not otherwise be possible.
- Contributors get encouragement for additional data collection.
- Publication of results is more feasible and likely to occur.
- At least three main issues require resolution:
- Rights of contributors need to be protected.
- Handling time, particularly given the absence of an automated matching system, increases as the catalog expands.
- Funding.

Barlow pointed out that by signing on to the SPLASH program and providing photographs, contributors implicitly endorse the program's main goals. However, they also reserve the option of applying to the steering group to use SPLASH data in ways other than those specified within the program's design.

False Killer Whales around the Main Hawaiian Islands: Mark-recapture Estimation of Population Size

by
Robin W. Baird
Antoinette M. Gorgone
Daniel L. Webster
Daniel J. McSweeney
John W. Durban
Allan D. Ligon
Dan R. Salden
and Mark H. Deakos

The current best estimate of population size for false killer whales in Hawaiian waters is 268 (CV = 1.08) (Barlow, 2003). This population is considered strategic because estimated annual removals by the Hawai'i-based longline fishery for swordfish and tuna exceeds the Potential Biological Removal (PBR) level.

Baird summarized his group's findings on false killer whales from boat surveys between 2000 and 2004 (see Baird et al., 2005a). False killer whales were encountered on 14 occasions (2.9% of all odontocete sightings), in 8 of the 10 months with survey effort, and in three of the four subareas of the study area (i.e., not in Kaua'i/Ni'ihau). They were seen in water depths of 37 to 3950 m. Photographs were available for analysis from those 14 survey sightings as well as seven opportunistic sightings. Seventy-seven percent of the individuals photographed had markings sufficient for long-term recognition (i.e., from one year to the next). Seventy-six distinctively marked individuals were identified, and 47 of these have been seen on two or more occasions. Mark changes were documented for 10 individuals, but the rate of mark change was low (ca. 1 change/6 yr). Resightings suggest considerable movement between islands; for example, 19 of 21 individuals identified off O'ahu have also been recorded off the island of Hawai'i or around the "four islands." A multisite mark-recapture analysis, taking into account the proportion of marked individuals in the population, gives an estimate of 123 (CV = 0.72), which is not greatly different from the estimates by Mobley et al. (2000) and Barlow (2003). This estimate applies to a population of whales that occurs in the study area but whose total geographic range is uncertain. The method of estimation assumes population closure and homogeneous capture probabilities among individuals. A longer time series and larger sample size are needed to examine the potential biases and increase the precision of the estimate.

The aerial behavior of killer whales makes groups relatively easy to detect. Photo-identification depends almost entirely on dorsal fin features; wounds heal black on this species, which means that scars tend not to provide useful mark information. Baird reported that about 50 biopsies are currently available from false killer whales in Hawaiian waters, and genetic analyses by Susan Chivers have indicated that the animals are reproductively isolated from those in the eastern tropical Pacific. As mentioned earlier, Baird intends to carry out some radio or satellite tracking of false killer whales in the near future.

Strandings and Emergency Response in the Pacific Islands Region

by
Bob Braun
and Chris Yates

Braun began this presentation by describing the Hawaiian Islands Stranding Response Group (HISRG). Interest in, and commitment to, investigating cetacean strandings in Hawaii surged when Sea Life Park, and to some extent the Navy at Kaneohe Marine Corps Base, began response and rehabilitation activities in the early 1960s. Eventually, Dolphin Quest Hawaii became interested and involved, but by 1993 the Navy program had moved to San Diego and by 1999 Sea Life Park and Dolphin Quest had withdrawn from participation. Thereafter and until 3 years ago, stranding response was even less organized and was essentially dependent on the initiative of individuals. In 2002, the HISRG was formed to provide first responses, perform necropsies, facilitate rehabilitation (when appropriate), support public education and outreach, and assist with sample disposition. The only criterion for group membership is that the person is at least 14 years of age and works well with others. The present executive board consists of Marlee Breese, Paul Nachtigall, and Bob Braun. There are about 300 participants, of which about 50 are core members, including 10 veterinarians with some marine mammal experience as well as marine biologists, animal trainers, and animal-care specialists with many years of experience with marine mammals.

The HISRG is a 501(c)3 nonprofit organization and, to date, it has been the recipient of three Prescott Grants. It is apolitical, not involved in enforcement, not a research body, and not an archive for marine mammal samples. The group's decision-making priorities center on human health and safety, the conservation of wild marine mammal populations, the welfare of individual animals, and the service of science, education, and public outreach.

Most of the group's work is carried out in the main Hawaiian Islands. There are active community-based subgroups in O'ahu, Kaua'i, and West Hawai'i; more are being organized. Funds and experienced people are available for work throughout the Pacific Islands Region.

The HISRG strives to:

- Coordinate verification of stranding reports through the network;
- Coordinate first responses to strandings;
- Assess stranded animals and coordinate their disposition from the stranding sites;
- Provide necropsy and animal-transportation services and assist in sample disposition;
- Provide Level A, B, and C data to the Pacific Islands Regional Office (PIRO);
- Provide temporary holding of tissue samples and data;
- Cooperate with the PIRO for disposition and analysis of samples.

In addition to activities related directly to stranding response, the group has engaged in development and training activities at the community level, e.g., through lectures, workshops, and meetings of various kinds. It has also sought to forge cooperative and collaborative relationships, an example of which is the use of a rehabilitation and necropsy facility at Marine Corps Base Hawai'i. Other collaborating agencies include the Stranding Coordinator, PIRO, NOAA Fisheries; Hawaiian Islands Humpback Whale National Marine Sanctuary, National Marine Sanctuaries; National Ocean Service; United States Coast Guard; Civil Air Patrol, U.S. Air Force; Marine Mammal Research Program, University of Hawaii; various divisions of the Department of Land and Natural Resources, State of Hawaii; county lifeguards, fire and police departments, and public works departments; and some businesses.

Cetacean stranding science priorities for the Pacific Islands Region, from the HISRG perspective, include:

- Develop functional PIRO regional marine mammal stranding coordination in the main Hawaiian Islands and expand effective policies and personnel into the other areas of the PIR.
- Develop relationships with the U.S. Fish and Wildlife Service and The Nature Conservancy to improve coverage in the Northwestern Hawaiian Islands and on Johnston and Palmyra.
- Work with National Marine Sanctuaries, the fishery observer program, and educational institutions in American Samoa.
- Develop relationships with DAWR, fishermen, USCG, USN, USAF, and the University Marine Science group in Guam.
- Develop relationships with the university in Saipan for coverage in the Commonwealth of the Northern Mariana Islands.
- Improve the information collected and dissemination of materials from stranding events in general.

The last of those priorities will require improved necropsy skills and practices, collection and reporting of life history data on stranded animals, development of user-friendly protocols for specimen collection and

distribution, and improved methods of disseminating information from each event. With regard to the latter, Braun anticipated worldwide web-based aggregation of: Level A data; a plain-language summary for the general public describing the stranded animal(s) and the event and interpretation, including cause of stranding, cause of any death, etc.; descriptions of rehabilitation outcomes (e.g., survival after release); and information on the availability, dissemination, and scientific use of samples.

The HISRG has sought to establish community-based response groups in areas where doing so was anticipated to be fairly easy, first in West Hawai'i, then Kaua'i, and now with some organization taking shape in East Hawai'i. A number of groups on Maui have assisted the HISRG in the past, and many of them are continuing to assess their interests and capacities to contribute in the future. With specific reference to Maui, Bernard stressed the value of working with lifeguards and the boating community and encouraged the distribution of posters and investment in outreach efforts.

Yates continued the presentation by noting that the PIRO was in the process of hiring a Regional Stranding Coordinator, with responsibilities for dealing with monk seals as well as cetaceans. The person in this role will need to emphasize facilitation and relationship-building because the NMFS will not have its own capacity to respond to the 20 or so stranding events that occur in Hawaii each year, much less those that occur elsewhere in the Pacific Islands Region.

In discussion, participants suggested that the new Coordinator should be encouraged to consult and interact with the marine debris program and consider the need and potential for developing disentanglement capability. Also, it was suggested that consideration be given to a visual health assessment program similar to that applied to North Atlantic right whales (Pettis et al., 2004).

Aspects of Oceanography in the Pacific Islands Region

by
Jeffrey Polovina
Lucas Moxey
Evan Howell
Frank Parrish
Don Kobayashi

Ocean conditions in the central Pacific are influenced by two major cyclic phenomena —the Pacific Decadal Oscillation and El Niño/Southern Oscillation. It is important to attempt to understand where we are on both of these cycles at any given time. Spatial patterns in five empirical orthogonal function (EOF) boxes are used as ecosystem indicators: Basin (120º E–100º W, 20º N–60º N), Equatorial (120º E–80º W, 20º S–20º N), California (135º W–100º W, 20º N–65º N), Alaska (155º E–120º W, 45º N–65º N), and Kuroshio Extension (120º E–140º W, 20º N–45º N). The Central Pacific Region (which contains the Hawaiian Archipelago) captures the dynamics of the Subtropical Gyre. There was a strong La Niña signal beginning in 1999, followed by El Niño signals in early 2003 and again in 2005. The eastern Pacific Region captures the California Current. There, the El Niño effects of 1998 and 2003 were almost the same in magnitude, and there was no real signal in 2005. The Northern Pacific Region experienced a shift in 1999 and had El Niño effects in 2003 and 2005.

Although oceanic waters around Hawaii tend to be highly stratified, there can be areas with large chlorophyll blooms in summer. Such blooms were observed in 1998, 2000, 2002, and 2004, and those that were sampled contained cyanobacteria. Neurotoxic amino acids are known to occur in cyanobacteria blooms. Indeed, a bloom sampled at Station Aloha in 2004 contained a neurotoxic amino acid. This finding raises the possibility of exposures with health effects on marine mammals around Hawaii.

Dynamic boundaries of water masses are likely concentration areas for high-trophic level species, including cetaceans. The Kuroshio Extension Current System (150º E–180º) is a "hotspot" for trophic transfer and thus a good candidate as a potentially cetacean-rich area.

Cold core eddies are persistent in the Hawaii region. Polovina's group is developing a variety of tools to track "eddy fields" and other oceanographic phenomena (e.g., acoustic scattering layers). For example, they are using satellite imagery (obtained directly from Godard) and deploying telemetric devices attached to living platforms that sample different depth strata (e.g., fish, turtles, marine mammals). All features have seasonal and inter-annual dynamics, and therefore require a long-term sampling strategy that addresses natural variability. The Coast Watch Program should soon be able to deliver large amounts of oceanographic data.

In discussion, Polovina indicated that his group would be able to provide the remote-sensing data back to 1994 that Forney and her coworkers need for their analyses of trends in the longline fishery.

Stable Isotopes, Inshore/Coastal Fishery Interactions, and Spinner Dolphin Habitat Mapping

by
Dave Johnston

Johnston identified three subject areas for future collaborative work: diet and trophic studies, documentation of cetacean interactions with inshore or coastal fisheries, and mapping inshore habitat used by spinner dolphins.

Stable Isotopes

Stable isotope analyses are widely used for diet and trophic studies of plants, birds, and other terrestrial and aquatic animals. Such analyses can determine diet composition and estimate an animal's relative trophic position over varying time periods, but with minimal disturbance (i.e., using tissue obtained non-destructively, either through biopsy of live animals or necropsy of dead stranded or bycaught animals). Initial effort will focus on false killer whales, using archived samples and possibly samples from captive animals to search for differences between sampling locations (e.g., near-shore vs. offshore, comparisons by longitude) as well as similarities or differences between animals associated with what is assumed to be the same localized food web. In general, stable isotope analyses may be used to augment information on stock structure at ecological time scales, shed light on the roles of various species in the ecosystem, and inform efforts to develop measures to mitigate fishery interactions. The immediate strategy will be to continue to collect samples (via main island surveys, observer programs, necropsies, etc.), assess the feasibility of using archived tissue samples, and arrange to have available samples analyzed in conjunction with monk seal foraging studies.

Near-shore Fisheries

Unmonitored near-shore fisheries in Hawaii represent a major data gap. Approximately 260,000 registered fishermen spend some 3.1 million days fishing in State waters each year, using a variety of gears and operating in various types of habitat. Handline gear is used both nearshore and offshore. In nearshore "longlining," the main line is usually less than 1.9 km long. Gillnets are used either bottom-set or floating, and trolling is commonly practiced. The steep benthic topography around the islands means that methods associated with "offshore" fishing are often used in State waters. Given that some cetacean species may occur in Hawaiian waters as small populations with limited distributions (e.g., false killer whale, pygmy killer whale, bottlenose dolphin), interactions with these unmonitored fisheries could be having serious but unrecognized effects.

To date, most documentation and regulatory effort has concerned federally regulated fisheries. Monitoring of State-regulated fisheries has been limited, with no observer programs. Thus, there is little data on total effort, by gear type, or interactions with cetaceans. Nor has there been any attempt to map fishing effort spatially and temporally in relation to cetacean habitat and behavior. Recreational fisheries are only lightly regulated.

A Sea Grant Federal/State partnership (Pacific Islands Regional Office/ Department of Land and Natural Resources) is beginning a series of "stakeholder surveys" to collect "narratives" of the nearshore fisheries and to identify and quantify fishing effort, by type, in nearshore Hawaiian waters. It will be the responsibility of the PIFSC to ensure that relevant data are collected on cetacean interactions and also that information on cetaceans is conveyed to participating stakeholders.

David Matilla pointed out that humpback whales are known to become entangled in crab trap lines off the northern coast of Oahu. Bernard noted that some work at collecting and collating data on nearshore fisheries has already been done by nongovernmental organizations and the University of Hawaii. To some extent, then, the task outlined here by Johnston might best be viewed as consisting of coordination and collaboration rather than establishing an entirely new and separate program.

Spinner Dolphin Habitat Mapping

Legal and management issues surrounding the use of bays for

daytime resting and socializing by spinner dolphins are a high priority. If such options as establishing closed or restricted-access areas are to be considered, there needs to be a good understanding of dolphin habitat use and behavior. Data on physical habitat features (e.g., depth, substrate; see Coyne et al., 2003) need to be combined with data on the distribution and behavior of the dolphins to develop a habitat model at various scales – archipelago, island, coast, and bay. A collaboration has already begun with the Hawaii Mapping Research Group to conduct fine-scale mapping of bays frequented by spinner dolphins on the Waianae coast.

Investigating the Sub-surface Behavior of Whales and Dolphins

by
Robin W. Baird
Daniel L. Webster
Daniel J. McSweeney
Allan D. Ligon
Michael R. Heithaus
Gregory J. Marshall

Baird listed several reasons why data on subsurface (diving) behavior has management value, as follows:

- To obtain surfacing and diving information for survey calibration;
- To evaluate exposure to depth-specific threats (e.g., fishing gear, high-intensity underwater sounds);
- To measure responses to potential threats (e.g., vessel traffic, sound sources);
- To investigate foraging behavior in relation to fishing activity or food web dynamics;
- To improve understanding of interactions with fishing gear.

Techniques for attaching tags to cetaceans include remotely deployed penetrating tags (for long-term deployments), surgically attached tags (for long-term deployments on small cetaceans), and suction-cup tags (for short-term deployments). Remotely deployed penetrating tags are not suitable for high-resolution sensors, have a high failure rate, and are expensive. Surgically attached tags are not suitable for high-resolution sensors, involve capture, can only be applied to small animals, and are expensive.

Suction-cup tags are useful only for short-term deployments. They can be pole-deployed on animals that bow ride (e.g., spotted dolphins) or on slow-moving species (e.g., pilot whales). Crossbow-deployment is most useful with approachable, medium-sized or large species (e.g., pilot whales, beaked whales). Suction-cup tags can be applied in capture-release programs as a way of monitoring an animal's short-term reaction to capture and the outcome of release. They can also be useful for monitoring the activities, movements, and survival of live-stranded cetaceans after their release back into the wild.

In Baird's experience, most cetaceans react to tagging by flinching and/or fast-diving but become approachable soon afterward and exhibit the same surface behavior as their companions. Some species immediately react by making high-speed leaps and spinning until the tag is dislodged. A typical suction-cup tag (Wildlife Computers Mk6/8 TDR), which is small relative to body size, samples depth (±1 m) and swim speed every second, along with light level and temperature. The "crittercam" developed by National Geographic is larger than the simple TDR. It is pole-deployed (suction-cup attachment, evacuated by a SCUBA tank), samples for up to 6 hours, and has a time, depth, and temperature sensor, sometimes with lights and an image intensifier.

Animals bearing suction-cup tags are generally followed in order to obtain skin samples for sex determination (tagged animal and companions) and to observe locations (thus determine water depths), behavior, and social affiliations (e.g., group size and composition).

Among the reasons that tagging and tracking are necessary for studying cetaceans are that these animals: (a) move long distances, (b) are individually difficult to follow, and (c) conduct important activities (e.g., feeding) underwater. Baird summarized the research goals of his telemetry work as follows:

- To elucidate factors (e.g., body size, habitat, prey choice) that influence diving patterns (e.g., through intra- and inter-species comparisons);
- To determine how sympatric species partition habitat and resources in three dimensions;
- To examine population- or species-specific diving patterns in order to inform management decisions.

Thus far, he and his team have deployed about 160 suction-cup tags and lost only about 4% of them. Tag loss rates are higher for deep-diving species (14%) and especially high for beaked whales (27%).

From 2002 to 2005, there were 14 TDR and 6 crittercam deployments on pilot whales in Hawaii, respectively resulting in close to 150 hours and 10 hours of acquired data. A clear pattern was shown, with the animals spending a few hours of every afternoon resting and socializing near the surface, then beginning to dive deep as light levels decline and the deep scattering layer approaches the surface.

Diving behavior was monitored for two Cuvier's and four Blainville's beaked whales in Hawaii (Baird et al., 2004, 2005b). Both species dove for periods of 48-68 minutes and to depths greater than 800 m (maximum 1,408 m for Blainville's, 1,450 m for Cuvier's), on average every 2 hours. Ascent rates for long dives were substantially slower than descent rates, while for shorter dives there were no consistent differences. Whales of both species spent prolonged periods of time (66 – 155 minutes) in the upper 50 m of the water column. Baird et al., (2005b) inferred that making extremely long dives causes the animals to push their physiological limits, resulting in compensatory behavioral mechanisms (e.g., slow ascent rates and prolonged periods at the surface for outgassing). These findings may contribute to understanding the effects on beaked whales of exposure to underwater noise.

False killer whales have very high levels of myoglobin in muscle, either for deep diving or fast swimming. A better understanding of the diving behavior of false killer whales will improve survey calibration (g(0)) and could also have implications for mitigating their interactions with longlines (e.g., dive depths vs. depths at which longlines are set).

Interactions between Cetaceans and Longlines: Estimating Interaction Rates and Serious Injury Determination

by
Karin A. Forney
Donald Kobayashi

The Hawaii-based longline fishery for billfish and tuna has been observed since 1994 (see Forney, 2004 for a preliminary report). Based on the observer data on cetacean incidental mortality and serious injury in this fishery, which exceeds the PBR level, the "Hawaii stock" of false killer whales has been designated as strategic under the Marine Mammal Protection Act. It is uncertain whether takes by longline fisheries are from a small, local Hawaii stock, a larger, wider-ranging ETP stock, or both.

Forney summarized the observer data from 1994 through June 2004 as follows:

- 15,869 observed sets;
- 55 cetacean hookings or entanglements;
- Heterogeneous data set with variable observer coverage by year (4% to 25%), varying set characteristics (depth, gear, location), and at least 10 different cetacean species taken;
- Fishing within the U.S. EEZs of three different islands or island groups, as well as on the high seas.

Interaction outcomes are classified into three categories: *D* = dead, *S* = seriously injured, and *N* = minor or no injuries. Of the 55 documented takes, 14 (25%) were not identified to species.

False killer whales killed or injured by longlines usually show evidence of having been hooked in the mouth. Forney noted that one priority arising from her analyses of the observer data is to develop a better way of defining and assessing "serious injury" (which is defined by regulation as an injury that is likely to result in death). Also, she expressed concern that a great deal more "injury" to false killer whales (and other cetaceans) may be occurring than what is reflected in observer data. Dorsal fin disfigurements observed on false killer whales in nearshore waters of the main Hawaiian Islands were interpreted by Baird and Gorgone (2005) as evidence that these whales had interacted with the longline fishery or other Hawaiian fisheries.

Heterogeneity in effort and interaction data arises from the following factors:

- Sets can be directed at "swordfish," "tuna," or "other," and these categories correlate with geographic areas, whether sets are deep or shallow, number of hooks per float, hook type, and whether sets occur at night or during the daytime.
- Regulatory changes and other factors affect the proportion of effort directed at the different target species or groups.
- Relevant characteristics have not been recorded consistently, whether in the captain's logbook (effort) or the observer's report (interaction rates).

The different types of longlining in the region—primarily targeting swordfish and tuna—have differing characteristics, including the cetacean bycatch profile. For example, Risso's dolphin is the species most often reported in the northern sector outside the Hawaii EEZ where primarily swordfish are targeted, while the false killer whale is the cetacean species most frequently reported as taken in the southern sector (including the EEZs of Hawaii and Palmyra) where the fishing is directed mainly at tuna. It is generally assumed that Risso's dolphins are attempting to remove bait, whereas false killer whales are removing caught fish. Although total effort appears fairly constant, the proportional allocation between the two fundamentally different types of longline fishing has varied considerably from year to year, primarily because of regulatory changes.

To address some of the challenges involved in estimating the cetacean bycatch from this heterogeneous data set, Forney (2004) initially pooled years and set types for the data from 1994 to 2002, assuming proportional sampling of the different EEZs, set types, etc. To reduce bias, Forney and Kobayashi stratified their estimates

of interaction rates by set type (tuna, swordfish, “other”), year (1994–2004), EEZ, species, and interaction outcome. This inevitably resulted in small samples sizes and large coefficients of variation. Among the types of things needed to improve the estimates were a better way of determining serious injury and a sensible method of assigning set types for the uncertain logbook and observer data. Regarding the first of these, advice was obtained from experts on marine mammals, fishing practices, and veterinary/health matters. Forney then established three possible types of observation that would lead to classification as serious: hooked internally (hook imbedded in mouth area or ingested), released with substantial gear attached, and swimming abnormally on release. Nonserious events were those in which the animal was hooked externally (e.g., body, fluke) or was released with little or no gear attached. Classifications were made on a case-by-case basis after scrutinizing the observer descriptions. Interactions with insufficient or no information were classified by prorating, based on those with sufficient information. For the second problem, Forney and Kobayashi used Classification and Regression Trees (CART) to assign effort and takes by set type and year.

For each effort type and EEZ area, annual mortality and serious injury for each species, M_s, was estimated as:

$$M_s = E_t * r_s$$

where

E_t = Total fishing effort by the fleet (# of sets)

r_s = Observed rate of mortality and serious injury of species *s*

$$r_s = (m_s + s_s) / E_o$$

where

M_s = Number of deaths of species *s* during all observed sets

s_s = Number of serious injuries of species *s* during all observed sets

E_o = Observed fishing effort (# of sets).

This analysis resulted in a much higher take rate for false killer whales in the Palmyra EEZ than for any other species or area. This is especially worrisome given the relatively high take rate of unidentified cetaceans in that area, at least some of which likely were false killer whales.

The strength of the genetic signal differentiating Hawaiian and ETP false killer whales is very strong (a haplotype difference, not just a frequency difference), which means it is relatively easy to assign specimens to stock when a tissue sample is available.

In summary, Forney concluded the following with regard to the analyses of Hawaii-based observer data from 1994 through June 2004:

- The classification and stratification approaches worked reasonably well although some problems remain (such as instances where observer coverage is estimated as > 100%).
- Sample sizes within strata are small, resulting in low precision.
- Estimates are more accurate than those presented in Forney (2004) because percent coverage by set type/EEZ has varied.
- They provide a tool for evaluating variables associated with higher take rates by species (e.g., set type, area, EEZ).
- For example, take rates of false killer whales in the Palmyra EEZ are estimated to be especially high: e.g., 3.5/1000 sets vs. 0.7/1000 sets in the Hawaii EEZ.

In discussion, it was pointed out that a major missing element in the existing analysis is consideration for fishery interactions experienced by the same whale population(s) outside the Hawaii and Palmyra EEZs. Distances to other jurisdictions (e.g., Kiribati) are short enough for this to be a plausible concern. Information

on stock identification and stock boundaries is key, but so is knowing more about movements by individual false killer whales. General support was expressed for the use of multiple lines of evidence to investigate stock structure; indeed, Baird's work has shown the feasibility of using photo-identification to supplement genetic analyses. To obtain information on individual movements, however, satellite-linked radio-tracking clearly offers a powerful tool to supplement photo-identification. However, in the case of false killer whales, the need to capture animals for tag attachment would likely make satellite tracking controversial, especially in view of the very low estimates of population size for this species in the Hawaii EEZ. Disagreement on this point could not be resolved by the workshop. It was suggested that further development of tags and attachment methods would be useful, and also that trial applications of capture and tagging techniques with a large population of false killer whales elsewhere could allay some of the concerns. Perrin pointed out that for small populations, genotyping from biopsies may be seen as a third line of evidence for individual movements.

Read called attention to ongoing mitigation efforts, such as development and testing of "circle hooks."

In response to a question concerning the origin and early development of the longline fisheries, Forney noted that they developed and expanded rapidly in 1991 following the United Nations ban on large-scale high-seas driftnets. Polovina added that the emergence of monofilament line had been crucial to the recent proliferation of longlining, and he noted that some boats around Hawaii had already started longlining by 1988.

Finally, Forney pointed out that the low take rates create a major perception problem. They tend to mask two other aspects that give cause for concern, i.e., the very large amount of fishing effort and the likely small population sizes for at least some of the affected species.

Surveys of Palmyra and Johnston Atolls

by
Jay Barlow

Barlow summarized briefly the Pacific Islands Cetacean and Ecosystem Assessment Survey (PICEAS) planned for the second half of 2005, to be carried out using essentially the same type of platform and methods as the HICEAS described earlier. The need to acquire better data on populations that interact with longline fisheries is a principal motivation for the PICEAS, and the focal survey area will include the Johnston and Palmyra EEZs as well as waters between them. The ship will tow a hydrophone array equipped with a special high-frequency component; an automated whistle classification system will be used to analyze the acquired data.

Biopsy sampling and photo-identification of blackfish (including false killer whales and short-finned pilot whales) will be a priority, as will extensive oceanographic sampling for data to apply in ecosystem models. Strategic Environmental Research and Development Program (SERDP) funding is available to support post-survey modeling of marine mammal density as a function of habitat characteristics (using Generalized Additive Models). Hildebrand queried Barlow about potential effects of hydroacoustics on sighting rates of cetaceans during surveys. Barlow considered the trade-off worth making and noted that studies to assess potential effects of active acoustics were in the planning stage.

Ecotourism Interactions: Spinner Dolphins and Swim-with Programs

by
Jan Östman-Lind

It has long been recognized that spinner dolphins in Hawaii use shallow nearshore waters as resting habitat during the daytime (Norris and Dohl, 1980). This habit puts them in potential conflict with human activities in the near-shore environment. A large and growing "ecotourism" industry takes advantage of the dolphins' presence by offering opportunities to observe and "swim with" them. The mode of interaction generally breaks down into either day trips (which can include diving, snorkeling, or kayaking) or "swim-with retreats" that last a week or longer. Some data from the Kona coast of the Island of Hawai'i provide an indication of the scale of the industry in 2002:

- More than 20 companies offering day trips;
- More than 50 retreats per year, each lasting 7–10 days;
- 6,800 boat trips per year;
- 135,000 person-days per year;
- 12,000 swimmer-days per year;
- Estimated revenue of $7.5 million in 2002.

Östman-Lind attempted to track the industry's size and growth by conducting an internet search in November 2002, starting with the term "Wild Dolphin Swim" (14,700 entries), then adding "Hawaii" (2,250), "Tours" (907), and finally "Kona" (332). A similar search in November 2004 (Wild Dolphin Swim + Hawaii + Tours) yielded about 10,000 entries; in May 2005, nearly 100,000 entries.

Shallow, protected waters suitable as resting habitat for spinner dolphins are limited to a few discrete sites on the Island of Hawai'i. Six primary resting areas have been identified along the Kona coast between Makako Bay and Kauhako Bay, and a single area (Kahena) is known to exist on the central east coast. In addition, there are 10 secondary resting areas and 2 probable resting areas on the Kona coast and 1 secondary resting area (Leleiwi) on the central east coast. Photo-identification studies have shown that spinner dolphins can be long-term residents, with more than 30 individuals having been resighted over periods of 14 years or longer along the west coast. One animal first photographed in 1979 was photographed again in July 2003.

The potential impacts of tourism activities on spinner dolphins have not been addressed as a funding priority in Hawaii. There is, however, a long time series of photo-identification and observational data, beginning with the work of Norris and Dohl (1980) in 1968-1972 and continuing into the 2000s with the work of Östman-Lind et al. In addition, shore-based observations of human-dolphin interactions in Kealakekua Bay have been carried out by Timmel and Courbis. Among the types of potential effects to look for are changes in: resting pattern and locations, social organization (e.g., school size, stability of social groups), acoustic and other behavior, and social interactions. Possible consequences of such changes would include decreased: nighttime feeding success (prey detection, social coordination); ability to detect or avoid predators and protect young; reproduction; and, ultimately, survival and population size.

Several approaches to measuring impacts were identified, as follows:

- Analyze trends in birth rate, population size, or school size.
- Identify (and quantify) changes through time in habitat use or resting behavior.
- Identify (and quantify) changes in acoustic behavior during mornings and late afternoons.
- Identify (and quantify) short-term (immediate) changes in acoustic behavior caused by harassment, using observations before, during, and after exposure.

- Assess day-to-day turnover (return rates) in resting bays.

For some of these parameters, considerable baseline data are already available, whereas for others there is almost nothing. Although a photo-identification catalogue containing images of several hundred individual spinner dolphins is available, a mark-recapture study (or a series of such studies) is needed to provide good baseline population estimates (a 2003 estimate of 855 – 1001 is already available for the Kona coast). The mean school size for Hawaiian spinner dolphins is in the range of 75-80, consisting of stable social groups of about 14 or fewer individuals. These social groups coalesce and split up on a daily basis but likely are stable over time. Östman-Lind's preliminary analyses suggest a significant reduction in the mean school size of spinner dolphins along the Kona coast between 1989 and 1992 and 2003, correlated with a rapid increase in swim-with activity there. Occupancy by dolphins of new "tertiary" resting sites has been documented. Overall, in comparing 1989-92 conditions with those in 2003, Östman-Lind noted that schools have become fragmented (they are smaller and more numerous), the dolphins have been displaced from some resting areas, and they are using new tertiary resting areas. Similarly, the spinner dolphin occupancy rate in Kealakekua Bay (percentage of days present per year) declined markedly from the 1970s to mid-1990s, again coinciding with a marked increase in swim-with activity in that bay in the late 1980s and early 1990s.

The following short-term research recommendations were proposed by Östman-Lind:

- Conduct additional mark-recapture studies to obtain multiple abundance estimates, taking full advantage of the 13-year data series for trend analyses.
- Assess historical and current birth and calf mortality rates.
- Conduct focal school follows to facilitate estimation of daily time budgets.
- Assess movement patterns.
- Monitor sounds of the dolphins and analyze their vocalization patterns in resting bays.
- Map and analyze habitat use.

Other presenters had also noted the need for a rigorous, formal process of habitat characterization for Hawaiian spinner dolphins. Equally, however, it was noted in discussion that the main goal should be to identify, measure, and monitor population trends, using whatever indices are appropriate and feasible. The time series already in place for mark-recapture estimates of abundance may offer opportunities for assessing trends. Also, it might be feasible to use a body condition index (e.g., girth) as a way to evaluate the consequences of disturbance (cf. Perryman and Lynn, 2002).

An additional priority is to obtain better information on stock identity. How many stocks or populations are involved? Östman-Lind noted that there is some evidence for movements by individuals around the Island of Hawai'i—i.e., suggestions that the animals found there belong to a single stock. Baird pointed out that there was photo-identification evidence indicating some level of interisland movement in the four-island area as well (also supported by unpublished observations by Östman-Lind). Participants agreed that a good understanding of stock identity is an essential element of assessment and management.

Lou Herman called the workshop's attention to a fish farm installed near a major spinner dolphin resting site. Collecting baseline data

should be a priority so that it will be possible to assess the effects of this development through time (although it is already too late to collect pre-development data at this site).

In addition to the immediate or short-term research priorities listed above, Östman-Lind cited the following longer-term priorities:

- Studies of daytime social organization and nighttime foraging, focusing on association patterns and cooperative feeding behavior;
- Studies of the parameters of social organization generally;
- Identification and description of resting areas for future protection;
- Acoustic monitoring;
- Double-blind studies in a resting area using a disturbance index (tracked from shore) and a probability of return (tracked from a boat);
- Studies of life history parameters;
- Studies of overall mortality rates;
- Comparative studies of offshore spotted dolphin and inshore spinner dolphin populations.

Ship Strikes and Whales: Super-ferry and Beyond

by
David Matilla
Jeff Walters
Lou Herman

Matilla had already covered this topic to some extent in his presentation on humpback whales (see summary above). Further, he called attention to plans underway to introduce the "H4" high-speed (83 km/h) ferry for inter-island transport in Hawaii, pending the resolution of an ongoing lawsuit. It was suggested that Hawaiian authorities should look to the Canary Islands and the northeastern United States, where high-speed ferries have been operating for a number of years in areas of at least seasonally high whale densities, for guidance on how to prevent or reduce the incidence of whale collisions.

Herman called attention to the rapidly expanding cruise ship industry in Hawaii, noting that the Norwegian cruise line, now under U.S. registry, makes passages between islands at night. Besides trying to raise awareness of the potential for collisions with whales within the cruise ship industry, Herman suggested that concentrated observational studies in particular areas (e.g., "The Slot" between Molokai and Lanai) might lead to the development of effective ship-avoidance measures. Real-time shore-based monitoring would be feasible in some areas.

Perrin pointed out that the International Whaling Commission (IWC) Conservation Committee had recently designated ship strike reduction as a priority issue. This may result in the development of useful modeling approaches for assessing and mitigating ship strike risks.

The Management Plan of the Hawaiian Islands Humpback Whale National Marine Sanctuary calls for efforts to characterize and monitor the effects of vessels on whales (National Marine Sanctuaries, 2002). In response, Lammers et al., (2003) reviewed evidence of ship/whale collisions in Hawaiian waters from 1975 to 2003. They ascribed the increased incidence of reported collisions to a combination of increased whale abundance and increased vessel traffic. Also, they predicted that the incidence would continue to increase in the absence of an effective mitigation effort. Lammers et al. suggested a public education approach that would include characterization of whale distribution and activity patterns along with dissemination of guidelines for collision avoidance in sensitive areas, such as reducing speed, posting a lookout, and knowing what to look for. In addition, they concluded that it is important to establish a centralized database on vessel-whale collisions that is well publicized and able to receive reports anonymously (on the

assumption that fear of enforcement actions by government agencies makes people reluctant to report such events). Standard information that should be sought for each event would include: photographic documentation (a ventral view of the flukes if possible), sex, body length, location of the incident, description of injuries (with photographs if possible), whale pod size and composition, type and speed of the vessel, and any other details on the circumstances surrounding the event. Finally, Lammers et al. stressed the importance of thorough necropsies conducted by experienced workers, noting that injuries from collisions can be very difficult to detect and assess.

Anthropogenic Noise and Cetaceans

by
Workshop Participants

The subject of cetacean acoustics was covered extensively in the presentations by Au, Nachtigall, Hildebrand, and Mobley (all summarized above), and the discussion under this agenda item on the effects of noise on cetaceans was brief. Ambient noise is clearly increasing throughout most of the North Pacific as a result of anthropogenic inputs, and there is currently no scheme or program of systematic, broad-scale monitoring. Suggestions were made concerning the potential for integrating a noise component into the ocean monitoring program at the University of Hawaii and for establishing closer links with ongoing efforts based at Cornell University. Given the recent interest in this issue at the national and international level, it is anticipated that NMFS will soon propose formal rules and science-based guidelines concerning thresholds of noise exposure for marine mammals.

Aquaculture and Risks to Cetaceans in the Pacific Islands Region

by
Lou Herman

Two open-ocean fish farms are currently operating in Hawaii. Cates began operations in 1999 and continues to raise moi (Pacific threadfin). Kona Blue Water raises amberjack. Three additional sites have been proposed and, according to Naomi, the aquaculture group within the State Department of Agriculture is considering 10 sites for future development. Areas deemed suitable for open-ocean fish farming will inevitably overlap areas used by cetaceans, at least to some extent.

Herman emphasized the importance of conducting before-and-after studies to evaluate effects of these operations on cetaceans and other marine life. As a basic approach, it would be useful to at least monitor the frequency with which cetaceans occur in or near the fish farm areas before, during, and after installation. In those instances where operations already exist, "sister-site" studies might be used to infer likely effects (cf., Watson-Capps and Mann, 2005).

The potential effects could range from entanglement in netting (Kemper and Gibbs, 2001) and exclusion from habitat because of anti-predator acoustic device transmissions (Johnston and Woodley, 1998), to greater mortality, injury, or harassment as a result of increased boat traffic and more frequent exposure to large sharks attracted to the sea pens. Herman knew of no plans to install anti-predator nets or employ acoustic deterrent devices at facilities in Hawaii.

Various science stakeholder groups were invited to present their perspectives on what the PIFSC should be doing and on how they might contribute to the center's work.

Science Center Perspectives

by
George (Bud) Antonelis (PIFSC)
and
Jay Barlow (SWFSC)

Antonelis began by describing a syndrome typical of scientific enterprise: the more we know, the more we claim not to know. The PIFSC gets its focus and direction primarily from the MMPA and Endangered Species Act. In general, the Center strives to achieve high-quality and relevant science efficiently, i.e., within severe budget constraints. It often functions as a "project manager," trying to generate requests for funding that are well justified and cost-efficient. Antonelis drew attention to two examples where existing programs—fishery observers and marine mammal stranding response—could benefit from scrutiny to ensure that they are: (a) generating the data needed to answer relevant questions for management, and (b) being fully exploited through analyses that address such questions. Antonelis also stressed the need to develop good baseline information on disease in marine mammals throughout the region, and emphasized the importance of establishing partnerships with other agencies and institutions to achieve research goals and objectives. He concluded by recognizing the critical importance of public support for the Center and its work, and thus the need for investment in outreach and public education.

Barlow, speaking on behalf of the Southwest Fisheries Science Center, noted that in the past, research priorities have been driven by the need to identify, characterize, and assess threats to marine mammals in Hawaii. The greatest immediate challenge to the new Science Center will be to pursue similar priorities elsewhere in the Pacific Islands Region. This will require a wide array of links and partnerships with individuals, institutions, and agencies in jurisdictions beyond Hawaii. Maintenance of a complementary relationship between the two Science Centers (PIFSC and SWFSC) will be necessary to take full advantage of their respective strengths. Interagency as well as inter-Pacific islands linkages should be cultivated (e.g., it was hoped that the Navy might help fund survey work in the Marianas).

Jason Baker suggested that options would need to be considered along three different axes: need, cost, and feasibility. In that regard, some activities, such as stakeholder interviews or stranding networks, could be viewed as "low-hanging fruit"—useful things that can be attained quickly and at relatively low cost. Setting priorities in a given part of the region may depend critically on what species and what kinds of potentially threatening activities occur there.

Regional Office Perspective

by
Chris Yates

Yates covered the regional office's activities in relation to stranding response in his earlier presentation on that topic (see above). In addition, he pointed out that the office is supporting Nachtigall's acoustic analysis work with stranded animals (see Nachtigall presentation, above) and seeking to ensure that there is adequate support for full necropsies of carcasses (see Ship Strikes, above). Yates also noted that his office is responsible for disentanglement coordination and oil spill response.

Fishery interactions are a regional priority, with the false killer whale a focal concern at present. Other species with high rates of interaction deserve close attention as they could also prove to be strategic stocks under the MMPA. It is important to learn more about depredation events and determine where, when, and how hooking occurs. Two research projects are being supported – one involving stable isotope analyses and the other documentation of nearshore fisheries. Future activities to be supported either directly or indirectly by the regional office include participation in an international longline bycatch workshop in Borneo (fall 2005), the PICEAS cruise to survey Johnston, Palmyra, and waters in-between (see Barlow presentation, above), the longline observer program's tissue sample and photograph collections, further analyses of stock structure and characteristics of depredation, and development and testing of approaches to mitigation.

The problem of harassment of spinner dolphins in their resting bays is another regional priority (see Östman-Lind presentation, above). Habitat mapping of baseline data is needed to assess population-level effects and to determine eventually whether mitigation measures are effective. A working group has been formed in collaboration with the PIFSC, OLE, State of Hawaii, and Marine Mammal Commission to address the management aspects of this problem.

Three emerging issues were noted: legislation and decision-making related to current and proposed aquaculture projects, ship strike mitigation in relation to fast ferries (and cruise ships), and the general problem of effects of underwater noise on cetaceans. For all of these issues, the regional office will need scientific background and support.

In discussion, participants encouraged the regional office to broaden its focus to encompass the rest of the Pacific Islands Region (i.e., other than Hawaii). In this regard, Yates noted that considerable information should be readily available from fishery observer programs in various parts of the region. Perrin pointed out that a large purse seine fleet operates out of American Samoa and that attention should be given to it as well as the longline fleets.

Western Pacific Fishery Management Council (WESPAC)

by
Paul Dalzell

WESPAC manages fisheries in Federal waters through five fishery management plans, which are being transformed into archipelago-based ecosystem management plans. With respect to longlining, interactions with false killer whales and short-finned pilot whales are a particular concern not only because of the injury and mortality caused to the whales, but also because of the economic effects on the fishermen—indeed, depredation rates can be very high and thus have major impacts on fishing profitability. WESPAC's goal of reducing/mitigating these interactions would exist regardless of how the fishery may be categorized under the MMPA. It has been noted that shallow sets targeting swordfish tend to have higher rates of interaction with cetaceans than deep sets. The swordfish fishery is currently constrained to 50% of the long-term average fishing effort and with "hard" caps on loggerhead and leatherback turtle interactions.

Dalzell was pleased to hear that nearshore fishing was slated for greater attention and scrutiny than it has been given in the past. All fishing in Federal waters, including trolling and handlining, may be managed in the future under a comprehensive Federal permitting and reporting system. It was noted that WESPAC has good relations with Japanese fisheries and fishery managers and is interested in learning more about their fisheries in or near the Pacific Islands Region. There are very large international pelagic fisheries immediately outside the U.S. EEZs, primarily Japanese and Taiwanese longliners, and the potential effects of those fisheries on marine mammal populations deserve closer consideration.

In response to a question, Dalzell stated that the Hawaii swordfish longline fishery has 100% observer coverage while the tuna fishery has 20% coverage.

NOAA Fisheries Headquarters

by
Michael Payne

Payne began by stating that from his perspective, "good science" is not just the best available science, but also science that is legally defensible. In the present context, both science and policy should therefore be guided, shaped, and driven by the prevailing legislative framework. One role of headquarters is to support science carried out by regional science centers, keeping in mind a national perspective. This applies particularly to the need for scientific input regarding recovery efforts. Payne acknowledged that most of the resources directed at recovery, per se, in the Pacific Islands Region would be going towards monk seals and marine turtles in the foreseeable future.

Fishery interactions (e.g., cetacean bycatch and depredation in longline fisheries) are an important issue at both the regional and national levels. Regional centers should be working closely with fishery management councils and leveraging various kinds of support from other agencies.

Another major issue from the national perspective is how to define management units ("stocks"). For example, how should genetics data be used and at what scale should such units be defined? This is bound to become a key question in the Hawaiian Islands, both for cetaceans and monk seals.

Continuation of humpback whale assessment surveys in Hawaii remains a priority in view of the possibility of a declining trend, as suggested by Mobley's 2003 results (see above). According to Payne, humpback research in Hawaii could be shared within NOAA, with the primary responsibility residing with NOS rather than the PIFSC. The NMFS has management authority for humpbacks, but the NOS Sanctuary Program has an existing infrastructure that could be used by NOAA to enhance research on this species, with the NMFS functioning as a partner. The PIFSC could then focus on fishery interactions and on issues surrounding small cetaceans.

Other issues of national interest include:

- Effects of anthropogenic sound on cetaceans (also a regional priority and a Navy priority);
- Managing the outcome of the introduction and proliferation of high-speed ferries in areas with high densities of cetaceans;
- Habitat characterization for spinner dolphins, swim-with activities and their potential effects on spinners, and related enforcement implications;
- Small take permits.

In discussion, Rivers asked for clarification of the roles of the region and headquarters in handling the ESA Section 7 consultations for naval activities around the Northern Mariana. Yates noted that such consultations needed to go through the Regional Office. Payne further explained that Headquarters has the lead responsibility to develop threshold exposure levels assumed to cause temporary threshold shifts and behavioral responses in cetaceans. He anticipated that an environmental impact statement on this matter would be issued by the end of 2005 and noted that draft values were already being used in some instances on an interim basis.

Herman registered his view that the fast ferry issue should not be regarded as only a matter of managing the outcome. As a ship strike issue, efforts should be made in advance to reduce or mitigate the risks to whales posed by the use of these vessels in environmentally sensitive areas.

State of Hawaii

by
Jeff Walters

Managing interactions between people and Hawaiian monk seals is one of the most pressing marine mammal issues in the main Hawaiian Islands. The issue includes adverse interactions (hookings and entanglements), with state-managed fisheries, and adverse interactions (disturbance of hauled out seals) with beach goers on popular beaches. The State also works closely with the NOS sanctuary office to support management and public education issues, particularly concerning humpback whales. For species not listed federally as endangered or threatened, the State's authority is quite limited. Nevertheless, within Hawaii, the problems surrounding spinner dolphin "swim-with" activities are high-profile and contentious. As discussed at length by Östman-Lind (above), these activities are expanding rapidly and represent a potentially serious source of disturbance to the dolphins. In addition to noting that the State has a role because of its authority to issue permits for launching kayaks, Walters cited three areas of

relevant needed research: population characterization (e.g., abundance, distribution, locations of resting sites), assessment of the biological or ecological impacts of "swim-with" activities, and social science studies to characterize target audiences, messages, and marketing strategies.

Again as mentioned earlier in the workshop (see above), ship strikes are a growing concern because of increases in vessel traffic and whale density in Hawaiian inshore and coastal waters. Relevant research topics identified by Walters include: development of whale detection/location technologies (vessel-, aircraft-, or shore-based) and analyses of spatial distribution data (fine-scale in "real time").

Finally, Walters identified open ocean cage aquaculture as a State issue. Of particular concern are large-scale projects having a "footprint" of 90 acres or larger. Relevant research topics include: fine-scale analyses of cetacean abundance and distribution in likely cage culture sites and identification and assessment of impacts such as collisions, entanglements, habitat loss, and habitat degradation.

In conclusion, Walters stated that State agencies have some resources to contribute as a PIFSC partner and he reminded participants to consider the needs of other islands in the region.

Following the presentation, participants suggested that State and Federal bodies should try to complement one another's enforcement and public education efforts with regard to spinner dolphin harassment. The humpback whale sanctuary, Sea Grant, and State agencies were mentioned as potential sources of support for public education initiatives.

Marine Mammal Commission

by
Michael Simpkins and Lloyd Lowry

Simpkins stressed two main points. First, the Marine Mammal Commission considers the plans and activities of the PIFSC as a high priority from a national marine mammal conservation perspective. This is reflected in the Commission's recent letters to various agencies (available at http://www.mmc.gov/letters/). Many of the topics discussed at this Honolulu workshop are consistent with the problems and concerns raised in those letters, including the recommendation that the PIRO hold the workshop.

Second, Simpkins emphasized the importance of proceeding in a measured and deliberate way. The scale of the research challenges facing the PIFSC is clearly far out of proportion to the resources available, and therefore great care needs to be taken in setting priorities and allocating those resources for optimal effects.

Lowry reinforced those points and urged that "low-hanging fruit" not be allowed to dominate the Center's scientific agenda (i.e., the Center should be selective). He added that there is need for balance between management and research. For example, in the case of spinner dolphins, it might be possible to address the harassment issue through management measures requiring little or no further research. It also might be possible to create new protected areas based on data already available. In this regard, Lowry encouraged more "data mining," i.e., applying creative types of analyses to take full advantage of data already available. Fishery observer data provide a good example.

During the ensuing discussion, Walters took the opportunity to highlight the importance of building scientific capacity within the region. To the greatest extent possible, research should be carried out by local investigators, with special emphasis on training and student involvement.

Hawaiian Islands Humpback Whale National Marine Sanctuary

by
David Matilla

Matilla drew attention to the 5-year management plan that provides a strategic framework for the Sanctuary's research and other activities (National Marine Sanctuaries 2002; also see presentation summaries, above).

U.S. Navy

by
Julie Rivers
Conrad Erkelens

Rivers provided an overview of the Navy's Marine Resources Assessment (MRA) process, a decision-making tool intended to help the Navy achieve compliance with environmental impact assessment requirements. The basic approach is to obtain as much relevant information as possible for sites where operations are underway or contemplated. Thus, the Navy regards cooperation and collaboration with the PIFSC and with NOAA-Fisheries more generally as a desirable mode of operation. It is assumed implicitly that with adequate information, the Navy will be able to accomplish its mission and at the same time avoid causing significant harm to marine mammals and other ocean life. Rivers noted that a large area south of Guam is currently being studied as a potentially "safe" site for operations.

Erkelens reported that the Navy has a strong interest in finding areas of ocean where its activities involving explosives and the generation of intense underwater sounds can be conducted without the constraints imposed when marine mammals are present. This process is referred to internally as Theater Assessment Planning, or TAP. To date, it has had little success at locating such areas in the Pacific Islands Region through aerial reconnaissance and deployment of passive underwater recording systems. In part, Erkelens attributed this difficulty to the fact that marine mammal populations are increasing in many areas. The overt, widespread concern about effects of mid-frequency sonar on beaked whales has fueled an especially strong interest on the part of the Navy in knowing more about the distribution, behavior, and ecology of this poorly studied group of cetaceans.

In discussion, Erkelens indicated that the Navy's present approach for small-take permit applications is to overlay "zones of influence" (based on estimated or assumed temporary threshold shift, TTS, levels) on cetacean density estimates to generate estimated take levels. The density estimates for many areas are derived by extrapolation of results in surveyed areas to unsurveyed areas. This is generally carried out in consultation with cetacean survey experts at the Southwest Fisheries Science Center. Perrin called attention to the fact that Japanese researchers have carried out extensive line transect surveys of cetaceans in the western Pacific, including waters near the Northern Mariana. There was a brief and inconclusive discussion about the tradeoff between attempting to obtain estimates directly for every area of interest vs. conducting surveys and monitoring intensively in one or a few areas for extrapolation.

In response to a specific question about mitigation measures related to naval training activities on Penguin Bank and in the "4-island area," Erkelens stated that there was presently no active transmission of tactical sonar at either of these sites.

In light of the foregoing concerns, the Navy can be viewed as a willing partner and a potential source of funding for survey work. Erkelens made clear, however,

that the Navy presently was not in a position to contribute resources for surveys around Guam and the Northern Mariana.

Given their clear interest in knowing, preferably in "real time," where cetaceans are and where they are not, it was suggested that the Navy place more emphasis on passive acoustics or on satellite imaging. Erkelens acknowledged the desirability of developing better (more efficient) ways of obtaining information that could provide an index of cetacean use of different areas at different times.

Guam

by
Thomas Flores

Flores reemphasized that Guam generally lacks the needed expertise and training in cetacean science. He also noted, again, the need for coordination and collaboration with agencies, institutions, and individuals in the Federated States of Micronesia and the Commonwealth of the Northern Mariana Islands. He identified naval training and testing operations along with commercial longline fishing as the most likely areas of potential conflict with cetacean protection in Guam waters. Necropsies of stranded animals and collection of tissue samples for genetic analyses may provide a basis for cetacean research initiatives in Guam.

American Samoa

by
Katerine Schletz Saili

The view from American Samoa is similar to that from Guam, with the exception that David Matilla's recently established program for studies of humpback whales in American Samoan waters (see above) means that some cetacean research activity is already underway there. There is local interest in developing the islands' own capacity to carry on other types of research in addition to that related to humpback whales. Training for necropsies, collecting samples for genetic studies, and participating in shipboard surveys (e.g., PICEAS) are ways to cultivate and develop that local interest.

Workshop Participants

Robin Baird suggested a scheme for setting research priorities based on a combination of risk and feasibility. Risk increases with:

- A decrease in population size;
- An increase in population structure;
- An increase in uncertainty;
- An increase in known threats.

It is unclear whether these factors should be given equal weight. Regardless, species or populations can be ranked in relation to each risk factor, and then the feasibility of studying the species and populations can be assessed according to encounter rates and behavior. In the case of Hawaiian odontocetes, consi erable

uncertainty exists regarding stock structure, population size, and risks for most species. In those cases where some evidence is available, it points to considerable structure and small population sizes. There is at least anecdotal evidence of risk for some island-associated populations – e.g., in the form of shooting and fishery interactions. Research is particularly needed to reduce uncertainty for pantropical spotted dolphins, rough-toothed dolphins, pygmy killer whales, melon-headed whales, Cuvier's beaked whales, Blainville's beaked whale, and short-finned pilot whales.

Lou Herman expressed concern that the shortage of funding available for basic research and the support of individual researchers in the Pacific Islands Region should not be allowed to result in stagnation of the development of new knowledge on species and populations in the region. He suggested that a fund of some kind should be set aside for basic research (i.e., not obligated for a specific application) to ensure that the research enterprise and the flow of ideas can remain viable. This suggestion was endorsed, in principle, by many other participants. It was noted as well that, in practice, support for applied research sometimes enables basic research to take place. Baird's studies of odontocetes in Hawaiian waters were offered as an example, where considerable basic research has been accomplished by "piggybacking" onto contract work for NMFS.

research priorities

The overarching goal of this research program is to provide the scientific information and advice required to conserve cetacean species and populations and protect their habitat in the Pacific Islands Region. In some instances, this will require more than simply maintaining the status quo: depleted populations need to be allowed to recover and degraded habitat needs to be restored to a healthy, productive condition. To the extent feasible, both research and management should be pursued using an ecosystem approach, bearing in mind the language of the Marine Mammal Protection Act referring to optimum sustainable populations and “the health of the ecosystem of which they [marine mammals] form a constituent element.”

In determining these priorities, two factors weighed most heavily: (1) perceived relevance to a serious conservation issue, and (2) extent to which a given research task was considered a, NMFS responsibility. Consideration was also given to the potential for leveraging, i.e., investing relatively small amounts of resources (usually in partnership with another agency or institution) to obtain significant new information. It was considered important not only to take advantage of opportunities that are affordable and achievable, but also to avoid allowing opportunities that might skew resource allocation and dilute efforts to address other priorities. Thus, an activity that addresses a clear management need (i.e., is necessary) and that is considered to be feasible and fundable over approximately the next 5 years would qualify as a high priority. It was expected that implementation of the recommended actions would involve an adaptive approach, i.e., plans would be subject to change as new information becomes available.

A further step that was not taken during the workshop, but that perhaps should be taken as a separate exercise, would be to organize the recommended work into three categories according to funding source: Center-funded (by PIFSC and/or SWFSC), “partner”-funded, and source unspecified.

In the following outline, items have been highlighted in boldface type and italics either because they were considered by workshop participants to be highest priority or because they were judged to be primarily the responsibility of the NMFS, as indicated.

A. American Samoa, Guam, the Northern Mariana Islands, and U.S. remote island areas

1. Generic priorities to be pursued in all areas

- ***Species inventories***—This need can and should be addressed using two relatively low-cost approaches: ***interviews to collect “traditional ecological knowledge”*** (TEK) and ***rapid assessment surveys***. In addition, focused studies to determine stock structure (using morphometric, photo-identification, and genetic approaches, preferably in combination) and stock abundance (preferably using dedicated line transect-type surveys) should be pursued as resources allow. Ideally, EEZ-wide surveys should occur every 3-5 years, and to the extent that it is essential to measure population on a broader scale or to which there are anthropogenic or other effects outside the EEZ, then throughout the wider range of these effects. ***Tissue sampling for genetic analysis*** should begin immediately by extracting DNA from available museum specimens and from any others that become available through stranding programs, bycatch retrieval, etc.

- ***Investigations of human-induced mortality and other threat assessments***—First steps should include ***fishery characterizations***

and observer programs, as well as the use of the TEK approach identified under Species Inventories.

- ***Training, capacity building, and collaborations*** *(both within the Pacific I*slands Region and with individuals and institutions outside the region).

- Habitat assessment.

2. Continued studies of population identity of humpback whales in waters of American Samoa, in part to address issues arising in the context of the International Whaling Commission

3. Surveys to meet the Navy's permitting requirements in waters of the Commonwealth of the Northern Mariana Islands

B. Hawaii

1. ***False killer whale***

   - ***Improved understanding of stock structure*** (e.g., defining differences between, and delineating distributional boundaries of, pelagic/offshore vs. insular/coastal populations) —Three main approaches are available: ***genetics*** (biopsy and necropsy sampling), ***photo-identification****,* and satellite telemetry. The last of these will involve or require the continued application of short-term tags and the development of long-term attachment methods.

   - Improved understanding of serious injury in longline fisheries (to be Headquarters-funded)—Analyses of scarring patterns may help.

   - ***Characterization of depredation in longline fisheries.***

2. ***Bottlenose dolphin***

   - Abundance estimates

   - Improved understanding of stock structure—using ***photo-identification*** and genetics (biopsy and necropsy sampling).

3. ***Spinner dolphin***

   - ***Improved understanding of stock structure—using photo-identification and genetics (biopsy and necropsy sampling).***

   - ***Stock-specific abundance estimates—using mark-recapture methods*** (*past and present*).

   - *Quantitative description and mapping of resting habitat.*

   - Assessment of population-level impacts of swim-with programs—This would require, among other things, monitoring the use of resting habitat by the dolphins in relation to the nature and amount of human activity in or near the resting sites.

4. ***Humpback whale***

   - ***Continued abundance monitoring—to include a 2006 replicate aerial survey.***

- Improved technical capacity and protocols to assess necropsy evidence of ship-strike as a causal factor in the animal's death.

- Fine-scale distribution of humpbacks in areas where risk of ship strikes is high.

- Population composition (e.g., age and sex structure) and demography in different island habitats.

5. ***Collaborative multi-species photo-identification catalog***

6. **HICEAS II survey**—It is important to recognize that these surveys are the backbone of the stock assessment process.

7. ***Estimates of cetacean mortality in other fisheries***—This will require efforts to ***characterize the fisheries***. Observer programs will also be needed eventually to obtain reliable quantitative mortality data.

8. ***Other odontocetes***

    - ***Completion of analysis of odontocete data obtained from Mobley's aerial survey time series*** (see Mobley et al., 2000).

    - Improved understanding of beaked whale distribution.

    - ***Improved understanding of stock structure and estimates of abundance for potentially rare insular species***—The pantropical spotted dolphin is an example of a species that is potentially affected by human activities (e.g., charter, sport, and commercial trolling) and for which considerable uncertainty exists concerning population stock structure and abundance.

C. Other Recommendations

1. **Strandings**

    - Development of protocols and priorities for collecting tissues from stranded cetaceans.

    - Dissemination of methods, protocols, and equipment for necropsies and tissue collection to other islands in addition to Hawaii.

    - Measurements of auditory evoked potentials in live-stranded cetaceans.

    - Prepare for increases in vessel traffic and potential collisions with large whales [e.g., high-speed ferry, etc.].

2. **Acoustics**

    - Development of a regional database of species-specific vocalizations.

- ***Remote acoustic monitoring in areas of special concern*** (e.g., Navy ranges).

- Documentation of species present in unsurveyed or poorly surveyed areas, with special attention to species rarely seen in the region (e.g., blue, fin, and minke whales).

- Trends in density.

- Monitor trends in ambient noise.

- Support for underlying research on the effects of noise on marine mammals.

3. **Other**

- Assessment of effects of open-water mariculture facilities. This will require development of assessment and monitoring protocols.

D. Longer-term Research

- Description and prediction of habitat.

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