Synopsis of Workshop on Passive Acoustic Monitoring of Cook Inlet Belugas: 6 November 2008

Alaska SeaLife Center Cetacean Research Program

ASLC Anchorage Office Conference Room
1007 W. 3rd Ave., Suite 100
Anchorage, AK 99501

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Agenda

Passive Acoustic Monitoring of Cook Inlet Belugas:
A workshop hosted by the Alaska SeaLife Center, Cetacean Research Program

8:00 – 8:30 AM	Continental Breakfast	
8:30 – 9:00 AM	Welcome *1) Introduction of participants* *2) Meeting purpose: Review acoustic data from 2008 and recommend future directions for Acoustics in Cook Inlet.*	Shannon Atkinson
9:00 – 9:15 AM	Cook Inlet beluga management *Cook Inlet beluga status* *Acoustic application for management*	Barbara Mahoney & Brad Smith
9:15 – 9:30 AM	Cook Inlet beluga research *Acoustic application for research*	Rod Hobbs
9:30 – 10:30 AM upper Cook Inlet	Movements, behavior and passive b monitoringbioacoustic monitoring in *Progress on:* ** Beluga behavior and bioacoustics in Knik Arm* **Towed array in upper Cook Inlet by A. Tomonari & B. S.Stewart*	Brent S. Stewart
10:30 – 10:45 AM	BREAK	
10:45 – 11:45 AM	Acoustics 101 *Environmental Acoustic Recorders (EARs), T-Pods, Towed-Arrays, Passive Acoustic Listeners (PALs), EARs* Passive Acoustics in upper Cook Inlet: *Progress* Passive Acoustics & T-PODS in Yakutat Bay	Marc Lammers
11:45 – 12:00 PM	Discussion of other acoustic projects	Workshop participants
12:00 – 12:45 PM	LUNCH	
12:45 – 2:45 PM	Discussion: What was learned in Cook Inlet during 2008? *Passive acoustic limitations in Cook Inlet*	Shannon Atkinson
2:45 – 3:00 PM	BREAK	

3:00 – 4:30 PM	Discussion: *Recommendation for future acoustic work to assist CI beluga management and research* *Acoustic sampling –*	Shannon Atkinson

Belugas	*1) Seasonal occurrence and movements, etc.* *2) Behaviors: feeding, migration, nursery, reactions, disturbance.*
Habitat	*3) Measure ambient noise conditions*
Monitor	*4) Baseline noise budget: ambient and anthropogenic* *5) Incidental Harassment Authorizations* *6) In-water construction (Port, Chuitna Coal.)* *7) In-water activities (shipping, dredging.)*

4:30 – 5:00 PM Wrap-up and Questions

Preface

In 2007 the Alaska SeaLife Center (ASLC) received an earmarked Congressional appropriation to work on Cook Inlet belugas (CIBs), and the decision was made to start a cetacean research program. The main focus of the program was CIB conservation, specifically any research that can lead to a better understanding of CIB biology and life history, as well as new or improved options for CIB management. This workshop was part of that award and the idea was stimulated in part by a 2007 workshop conducted by the Alliance for Coastal Technologies (ACT) on passive acoustic monitoring sensors.

When the conservation plight of CIBs resurfaced in 2007, the North Pacific Research Board (NPRB) chose to invest in an information workshop as part of the Alaska Marine Science Symposium in January 2008. We worked closely with NPRB, designing their workshop to be fairly general and the present workshop to be a more specific follow-up. The purpose of this workshop was to discuss passive acoustics research efforts in Cook Inlet. A second purpose was to develop recommendations on how passive acoustic monitoring could be used to study and manage CIBs.

Dr. Bob Small (ADF&G) and Ms. Barbara Mahoney (NMFS-Alaska Region) provided guidance on the content of the workshop, Ms. Jilian Chapman (ASLC) and Ms. Angie Steeves (UAF) provided administrative assistance. The workshop was funded by National Marine Fisheries Services and the Alliance for Coastal Technologies.

Presentations

NMFS Cook Inlet Beluga Management – Presented by Barbara Mahoney, NMFS-AK Region

A. Overview

There is a lot of interest in acoustics, but not much funding. Barb gave a brief overview on the laws governing Cook Inlet belugas (CIBs). The Endangered Species Act (ESA) was passed in 1973, and CIBS have been a candidate species since 1988. In 1999 NMFS was petitioned for the listing of this small population as endangered; to list CIBs under the ESA subsistence harvest was unregulated before 1999. Under the Marine Mammal Protection Act, (MMPA), CIBs were designated as depleted in 2000. In 2006 NMFS received a second petition to list CIBs as endangered. In 2007 CIBs were proposed endangered under the ESA. The population in 2008 was estimated at 375 in 2008 and was declining by 1.5% annually. In October 2008, CIBs were listed as endangered under the ESA and are defined as a distinct population segment (DPS).

NOAA Fisheries is legally required to designate critical habitat for the CIB population by October 2009. Economic analyses are needed to designate critical habitat. Under the ESA NMFS will 1) establish a recovery plan to develop a recovery team, designate critical habitat, and implement the recovery plan, 2) perform consultations among federal agencies, and 3) start the critical habitat designation process.

Potential Threats to CIB are:

1. Natural Factors
    A. Stranding – dead strandings, usually unknown causes.
    B. Predation – one attack on a beluga whale by a killer whale was observed in September 2008 and one dead beluga whale was found on a beach with evidence of attack by killer whales, and later was sampled in Turnagain Arm
    C. Parasitism and disease – Dr. Carrie Goertz and Dr. Kathy Burek have collected and analyzed tissue samples from whales for pathological analysis, among other things, that infect CIBs.
2. Human induced factors
    A. Subsistence harvest
        i. No allowed legal harvest during 2008-2012 because the CIB population is below a 5-year average of 350 belugas. The ‘floor’ at 350 animals is based on reproductive success and the estimated abundance during the harvest process.
        ii. To regulate subsistence harvest under the MMPA, NMFS held an administrative hearing. The administrative law judge agreed that no harvest should occur when the 5-year average

is below 350 belugas. If the previous 5-year average (2008-2012) is above 350 belugas, subsistence hunting would be allowed during 2013 - 2017.

  iii. Co-management agreements were developed between NMFS and Alaska native organizations.

B. Poaching – enforcement via airplane, boats, and vehicles.
C. Oil & Gas Development
D. Vessel traffic
E. Tourism
F. Noise
G. Research effects

B. Questions

1. How does ESA listing affect the research permit process?
    A. NMFS-Permits will consult with the region, and all activities with a federal nexus are subject to consultation. If proposed work is non-invasive or does not alter the behavior of the CIB and belugas are not affected, no consultation is needed. If the proposed work is invasive, or belugas are affected, consultation is needed and likely an EIS as well. Cook Inlet belugas have occupied marine habitats in the most industrialized area of the Alaska. Management concerns and approaches are critically important for conservation of CIBs and somewhat parallels those of north Atlantic right whales CIBs subsistence.
2. Which beluga count does NMFS use when two video cameras, both zoomed and wide angle, are used?
    A. NMFS compares 3 Zoomed video focuses on small gray belugas, while the directwide angle videos are used on the whole group
    B. Results of the analyses indicated substantial differences in estimates of numbers of whales when they were congested but were more similar when they were dispersed.
    C. Observers watching a tight beluga group were overwhelmed and had a hard time getting accurate counts.
    D. Results of the analyses indicated substantial differences in estimates of numbers of whales when they were congested but counts were more similar when they were dispersed. belugas in
3. Are close-ups (zoom video) used to correct counting (wide angle) videos taken by NMFS?
    A. Based on the image size, NMFS has developed a correction factor from video analysis for missed pods, missed calves, and missed non-calves.

NMFS CIB Research & Acoustics – Presented by Rodd Hobbs, NMFS/NMML

A. Overview

Rodd Hobbs has conducted research on beluga whales for the past two decades and has been involved with aerial surveys of CIBs since 1993. The primary responsibility of NOAA Fisheries for beluga whales is to document abundance and distribution by aerial surveys. Standardized surveys have added more sophisticated technology since the start, but the methods is largely unchanged. Aerial surveys are flown at 800 feet. The average survey is 10-12 days in June and includes most common habitats, coastlines, and upper Cook Inlet. The goal of the surveys is to locate groups and then count them as accurately as possible. Surveys of lower Cook Inlet usually occur over two days. CIBs are generally distributed along Lower inlet tidal flats between Beluga River and the Little Susitna River, and also Chickaloon Bay and Knik Arm. Surveys are conducted at low tide or starting at incoming tides when the whales are more concentrated. Each whale group is circled 10 to 16 times depending on group size and environmental conditions. Video data and multiple counts from paired (two) observers are obtained.

For counts made from video data, 3 to 4 good group passes are sought. Wide angle and zoomed video cameras are paired, and computer-enhanced counts of belugas from video data allow belugas to be specifically identified. Estimated abundance of CIBs declined from 653 to -375 between 1994 and 2008 belugas.

B. Potential use of acoustic data for estimating abundance of CIBs

1. Beluga aerial survey – are all large groups in the CIB survey area? NMFS assumption is that whales are in the survey area. If estimates of the abundance vary greatly from day to day, is this owing to movements of groups in and out of the survey area?
    - A. Monitoring of the area with acoustic methods might indicate the extent of movements and their effects on abundance estimates in the survey area.
    - B. Maybe it could be determined which whales were around with acoustic recorders when the survey plane is above. Is it possible to relate beluga acoustic behavior to surface behavior?
2. Beluga calf counts
    - A. Can calves and/or calf-pair interactions be identified with acoustics?
        - i. Relative calving rates.
        - ii. Juvenile-adult ratios from acoustics
    - B. Population extinction risk used varying models that ranged from 30-75 percent by 2308
        - i. Include killer whale mortality and other factors.
        - ii. To improve on population model
            - a. estimate number of predation events

b. estimate amount of time and number of belugas that spend time in areas of a point source mortality.

    i. Maybe we'd find that belugas are around the sewer outflow or some other area.

3. Beluga extinction risk assessment
    A. Need to assess general human impact to beluga acoustic environment.
4. Beluga range contraction (1978 – 1997)
    A. Years ago belugas were observed mostly in used lower inlet, where they were centered around Kalgin Island, and where they are rarely seen there now. In the early 1990s CIBs were primarily seen near the mouth of the Susitna Rivers. Their range has evidently contracted even more and it appears to now be centered around Point Possession, Knik Arm, and Little Susitna River. Satellite tag (2002-2003) data indicate that CIBs concentrated more around the north end of Cook Inlet from August through November and then were more dispersed from December through March, most likely due to distribution of their principal prey.
    B. Can beluga habitat be predicted through modeling?
        iii. River flows into Cook Inlet helps determine fish runs and availability, critical elements to CIB distribution.
        iv. Timing of fish runs in upper Cook Inlet may affect modeling perameters.
5. Beluga distribution
    A. Need to map acoustic environment by season and year
    B. Need to relate current acoustic environment to the past
        i. Correlate changes in human activities and natural changes in the inlet
    C. Estimate injury and interference risks to belugas (in relation to behavior)
6. Beluga feeding and diet
    A. Beluga stomach content analysis
    B. Analysis of stable isotopes in tissues
    C. Identify vocalizations associated with
    D. Acoustic identification of prey and prey types
7. Beluga predation by killer whales. Maybe listening to sounds when belugas are aware of killer whale presence? Killer whale predatory
    A. Acoustically identify feeding – correlate with presence in feeding areas
    B. Acoustically record beluga 'behavior' with killer whales present.
    C. Acoustically identify predation, sounds such as "bones crunching" may be audible.

C. Questions

1. Are there any relationships between the body of a whale that can be seen on the surface and its vocal activity? Is there a way to detect that, or have enough resolution when zooming in with video cameras?
   A. Typical behaviors
      i. Standard roll – 2-5 seconds at top the surface.
      ii. Head lift, breathe, and go down (shallow water).
      iii. Dive tag data: belugas surface for 10 seconds and then dive under water, which could be for three minutes.
      iv. Beluga groups observed during the June 2008 survey, we may see different behaviors were seen, but those could be that belugas breathe every 20-30 sec and were not spending much time under water.
2. Are there brief summaries, reports, or publications of data collected with dive tags?
   A. Longest tag lasted 10 months.
   B. CIB satellite tag report: measured ARGOS locations, summarized dive data for six hour periods, provided time at depth histograms and dive duration.
   C. Tag data has been analyzed, but not analyzed in relation to habitat features.
3. How do CIBs use the water column?
   A. CIBs mostly stay in shallow water. Not much information published on beluga behavior in water column.
4. Is there information to show that belugas react to aircraft and/or a circling survey plane at 800 feet.
   A. NMFS has considered this. On one occasion NMFS looked to see if belugas react to the survey plane. Once, the aircraft passed the beluga group and the whales came to the surface and stayed for about two minutes. NMFS simultaneously listened, via VHF tag, but no changes were observed in the group size estimates. If belugas change behavior during surveys, this behavior is something they maintained through the entire encounter. The airplane noise is behind the plane so belugas are observed before they could hear the plane. However, NMFS believes whales are not reacting to the plane noise.
   B. When the survey plane is below 800 feet, due to requests by the control towers, the whales appear to dive beneath the surface.
   C. When small planes are observed flying over beluga groups, and when the aircraft flies by, circles, or flies overhead. those planes are low (less than 800 feet) and belugas tend to dive and stay below the surface.

Movements, behavior and passive bioacoustic monitoring in upper Cook Inlet – Presented by Brent Stewart, HSWRI

A. Overview

The interaction between beluga whales and boats in Knik Arm was the focus of the study, which and had two prongs:

3. Planned – studies on beluga behavior and movement patterns to assess beluga movement patterns around vessels and document their interactions. Focal animal and group observations (land based observation) were recorded with two methods as extant NOAA permits did not allow close approach of whales. Photographs were taken opportunistically to determine habits of individuals and groups. Key activities of CIBs mid-August to mid-September included: calving, foraging, protection and nursing of calves and socializing, staging, and re-establishment of groups in particular areas. Preliminary conclusions:
    A. Movement patterns varied daily.
    B. Distinct use of particular areas for foraging, transit, and socializing.
    C. Interaction with boats uncommon, but whales did respond to close moving or approaching boats (up to several hundred meters away) with a change in behavior when boats passed.
4. Ad hoc and supplemental opportunistic studies – Application of acoustic monitoring system that was used during surveys for river dolphins (baiji) and Chinese finless porpoise in the Yangtze River in late 2006 that succeeded in determining group sizes from monitoring of porpoise vocalization (several publications). Two recording systems were used on a single towed hydrophone array:[1]: i) A-tags (acoustic data loggers) mounted 10cm apart for high frequency monitoring and ii)low frequency array. Preliminary results were:
    A. Vocalizations varied with behavior and location
    B. Distance of sound source from the array could be calculated by incorporating speed of boat and analyzing change in the angle from the boat to the vocalizing whales.
    C. Detected vocalizations to a 471m was the maximum distance of to the whale or whale group.

B. Questions

1. How many animals in a group could you potentially detect?
    A. Depends on context (e.g., feeding in congested groups or travelling in transit between feeding or aggregating areas). Potentially all of them, particularly if they are more dispersed. Generally detected fewer than entire group however, and only recorded about two whales because they were often congested. More thorough investigation

[1] Recording devices were successfully used during the Yangtze River acoustic studies and results have been published.

would require issuance of need an Incidental Harassment Authorization (IHA) or Level A harassment permit so that a boat could approach more closely with hydrophone array.

2. Is the recording system gauged toward getting location or bearing?
    a. These are related. The boat is constantly logging it's geographic location. The array system determines bearing and distance to the whale or whale group and can then integrate the two sources to determine geographic location of the whale or whale group. was plotted the
3. How do you get distance measurement without knowing the source level?
    A. The source level in not needed as a parameter with multiple hydrophone array as the difference in reception time to each hydrophone in the array is measured. Distance to the whale group is determined by simple geometry.
4. Can you detect acoustic signals associated with feeding?
    A. There were two types of clicks that detected that may have been associated with feeding. The distance of boat to whale groups was too great to determine which type was being emitted by which whale. At times, whales were silent whereas they were extremely vocal (as a group) at others. When travelling fast in transit they appeared to be quieter and underwater longer. Filtering of background noise from the recordings will take a bit more work.
5. During what time period this was done?
    A. The first week of August through mid-September when previous reports indicated that whales would be most common in and near Knik Arm.
6. Was there a noise signature between adults and calves?
    A. The distance that I could approach whales without a MMPA permit was too great to evaluate this, but likely could be done with closer approaches.
7. What is the effective detection range?
    A. Detection range was just under 500 m during the tests of our systems acoustic to determine beluga bearing, location, and distance.
8. Are you doing this in real time?
    A. We listened to the active hydrophone arrays constantly and were able to hear vocalizing whales. Determination of number of whales in the groups or location of individual whales vocalizing requires post-processing of audio recordings.
9. Can you continue this work based on what you've been able to glean so far? What should we do next summer?
    A. Yes. Follow up could be helpful for calibrating groups sizes and perhaps composition of whales seen during aerial or ground-based survey data. A key issue in follow up studies would be to spend more time on the water near groups and following movements of groups.

Tides limited access to boat ramps and work schedules of NOAA Corps collaborators, so it would be useful in further studies to have a vessel that could spend several days or more on the water to follow groups of whales or station in areas where whales are aggregating or transiting.

10. Could you work in 2 m of water with the acoustic array?
    A. Depth is not the critical issue, to the extent that the boat may have to be moving constantly with some hydrophone monitoring systems. With single directional stationary hydrophones or buoyed paired hydrophones the boat can remain stationary (anchored) or drift. Towed hydrophone array requires that the boat be constantly moving and circling takes a wide arc and increased speed to keep the array from dragging on the seafloor.
11. What kind of background noise would you have to deal with? Are other configurations possible?
    A. Stationing an array in Cook Inlet would be an option. One critical variable is to know the position of receivers (must be a constant). In area with lots of current that becomes a challenge.
12. How do you address problems with tight beluga groups?
    A. The times when belugas are underwater and quiet are a challenge, as are the sounds produced when they are at the surface in more congested groups and socializing. The inference is that belugas are searching for food or each other when vocalizing. Vocalizations associated with foraging might be distinguished from those associated with non-foraging activities. Potentially could be delineated from socializing sounds.

Acoustic monitoring for beluga presence in Cook Inlet – Presented by Marc Lammers, HIMB

A. Overview

Marc's understanding is that one of the biggest concerns for CIBs is to determining beluga patterns of use of in Cook Inlet generally and key habitats particularly. Belugas have been referred to as "canaries of the sea." They are not acoustically active all the time, but have periods with high vocal activity and others when there is little, perhaps vocal activity associated with resting.

Belugas produce a variety of sounds ranging from 2 kHz to 100 kHz. Audiograms demonstrating hearing sensitivity were done, including evidence for loss of sensitivity to high frequencies with age. There are several challenges when recording vocal activity:

1. Low frequency vocalizations can be recorded relatively easily with a minimum of computer resources but need for computing resources increase with frequency content of sounds.

2. Field recordings of high frequency sound have been difficult but great advances during past two decades.

Beluga calls (tonal) or whistles are long duration (0.5-2.0 seconds) and low frequency (ca 2 kHz and 10 kHz) compared with dolphins (e.g., dolphin frequency is up to 20 kHz). Beluga clicks last 70-80 microseconds, high frequency and high amplitude (100+ kHz) and are produced for echolocation, but might also play an important role in social communication. Beluga clicks are produced in burst pulses (suspect no function in echolocation) and are often seen in aggressive behavior. When they produce pulses of sound in trains, they are rapid sequences 100 milliseconds (0.001 seconds) apart.

With broadband signals high frequency attenuates faster than low frequency. Thus, the spectrum drops with distance. Shifting amplitudes will change dominant frequency and echolocation pattern in response to ambient noise. Belugas also will change frequency according to their activity.

Beluga call patterns were played from recordings and sonograms showed bright colors for higher intensity and frequency. Impedance is different in air versus water. Sound produced in one medium will reflect or refract at the surface of the other medium depending on its incident angle and either slow down or speed up If a sound is produced in tissue then it will be well coupled with surrounding water and transmit well. Sound produced in air will not transfer into water well unless coupled by a well conducting conduit (e.g., a beluga sticking its head out of water may or may not be heard). Sounds are produced from the beluga's melon.

B. Recorder Types

1. Passive Acoustic Listeners (PAL)
    - A. Originally designed to record acoustic meteorological events (rain, hail, etc.)
    - B. Limitations – aimed at recording certain events for short time intervals.
2. High-frequency Acoustic Recording Package (HARP)
    - A. Developed at Scripps Research Institute
    - B. Cadillac of acoustic recorders (~$30,000)
    - C. High frequency capabilities - can record up to 200 kHz
    - D. Can record several terabytes of data (weeks or months at a time)
    - E. Can record on a schedule to extend deployment and battery life
    - F. Great when you want to record all noise signals, all the time, and/or in deep water (1000m)
    - G. Trade-off is that a lot of time nothing happens
        - i. Huge volume of recording data can be overwhelming, with limitations in processing, 95 percent quiet time
3. Porpoise Detectors (T-PODs)

A. Bill Lucey will talk more about this later
B. Used widely in Europe for harbor porpoise studies
C. Designed and manufactured in England
D. It detects events, instead of recording sounds
E. Listens for acoustic signals indicative of echolocation clicks
F. Programmed to record at specific frequencies
G. Limited to recording clicks at/and/or high frequencies
H. Also relatively inexpensive I (~$3,000)

4. Ecological Acoustic Recorder (EAR)
   A. Microprocessor-based system.
   B. Records frequencies at 0kHz to 30 kHz, which includes: dolphin whistles and calls; and lower frequency clicks.
   C. Designed to deployment for extended periods of time.
   D. Designed as a low-power and low-cost recorder system.
   E. Now hope to record up to two years from some cetaceans.
   F. Does not record all the time.
      i. Schedule the recordings (ex., 30 second recordings every 15 minutes during one year or maybe 30-60 second recordings every 5 minutes during one year.
         a. Observe patterns by maintaining battery power
      ii. Samples the ambient sound field to document a pattern of events.
      iii. Has been an effective tactic; have seen patterns in fish sounds, day/night differences, when animals come in an area, how long they stay in an area.
      iv. Recordings are raw data, not compressed data.
   G. Event detection function
      i. Sound comes in, recording is triggered by frequency and amplitude.
      ii. Program to record for specific durations for specific criteria.
      iii. Can be used for vessel monitoring (poaching, boats using gear when they shouldn’t be, etc.)
      iv. Records other loud sources (ex., other whales, fish eating algae on the recorder, etc.)
   H. Ability to record only high frequencies.
      i. Has not yet been enabled – not fully functional, yet.
      ii. If frequency threshold is too sensitive, you record everything (garbage data).
      iii. Battery and deployment life will be short
   I. Event detection, high frequency, and duty cycle can operate simultaneously to start recorder.
   J. Can you set EARs into an array?
      i. No, EARs do not communicate with each other or outside the environment.

ii. Presently they are loggers only
    a. One could find a way to link EARs.

K. Deployment
    i. Anchor (concrete block) the EARs.
    ii. Release the EARs by divers or acoustic releases.
        a. Syntactic foam floatation collar.
            a. Attach to acoustic release (redundant system), which operates independently from the EAR.
        b. Recorder will surface when a specific frequency is transmitted through the water which will trigger a release.
        c. EARs deployed in Cook Inlet were placed at 40-80m deep.
        d. Acoustic releases has a range function and the transducer can be programmed to range so your boat can tell distance to the release.

C. Objectives of the ASLC/ADFG work (pilot effort)

1. Test EAR deployment methods in Cook Inlet conditions (i.e. sediments, tides, etc.)
2. Determine whether EAR records belugas.

Two prototypes were developed, including one jumbo EAR and two conventional EARs. Both were fitted with hydrodynamic housings. The conventional EARs were recovered. The two conventional EARS recorded during the entire deployment period. The one jumbo EAR was not recovered. What caused this recovery failure? The release mechanism worked, but foam used to fill the jumbo EAR (yellow submarine) was not watertight and likely became heavy with silt.

About 25,000 recordings were obtained collected from the two EARs and automated data processing software was used to sort through it. We looked for specific sound recordings by creating templates that searched for certain sound patterns. This method doesn't always work, so it helps to look at the amount of tonal signaling (beluga calls). Tonal signaling is focused, produces sharp peaks in a tonal spectrum and records for how long the signal was tonal. It allows you take thousands of files and tells you the percent of the time there were sounds that match the tonal spectrum. This method allows review of only a few hundred files instead of thousands of files or recordings.

There was substantial background noise in Cook Inlet. We excluded recordings that were obviously loaded with vessel traffic. Those where beluga vocalizations were detected were mostly noise-free. Two recording sonograms were presented: 1) beluga sounds and 2) tug engine sounds. The beluga and tug engine sounds overlapped greatly, making it hard to parse out beluga noise (both are at 0-5.5 kHz). Sounds were recorded up to 20 kHz and the signal-noise ratio was examined to possibly set the threshold lower, however that can result in more false positives of CIB sound recordings.

D. Cook Inlet Detections

On 28 and-29 June 2008, the belugas were detected around the same time of day (probably coincided with beluga movements associated with tides) for the mooring EAR site near Fire Island. The detection range was conservatively estimated at 1-2 miles based on a simulated high frequency signal from a skiff at varying distances. Low frequency sounds travel farther than do high frequency sounds, so the detection range could be greater for low frequency. If an acoustic signal is 1-2 dB above ambient noise evidence of a signal will be detected. Visual inspection of recordings probably the best way to detect vocalizations. Automatic software and algorithms are generally just simple filters. Processing with these algorithms takes substantial amounts of time. The shape of the beluga call pattern is not used to detect belugas. The Port McKenzie EAR location only had four detections. This may contraindicate the need for more EARs deployed at Port McKenzie if heavy ship traffic masks beluga sounds.

E. Conclusions/Lessons Learned

1. If we put EARs almost anywhere else in Cook Inlet, besides where we did, success would likely improve (ie. more beluga recordings).
2. Conventional EAR deployment method is feasible in Cook Inlet.
3. It remains unknown what would happen to the EARs in winter conditions.
4. There was concern about flow (background) noise due to strong currents (up to six knots), but it was <1 kHz and not a major problem.
5. All detected beluga calls were <10 kHz, which would allow for fewer sampling rates and therefore, longer deployments for the future.
6. Biggest challenge is industrial noise.

F. Future directions

1. Refine algorithms to improve beluga noise detection efficiency
2. Explore deployment under ice (winter conditions)
    - A. Concerned with additional background noise (tides and ice) and with ice sweeping EARs away
3. Deploy more EARs to cover more area

G. Questions

1. Have you reviewed Port McKenzie beluga observation data?
    - A. No – if available we would like to.
2. Could you shield one side of the recorder if you know traffic is heavier on one side?
    - A. You would need to build a structure proportional to the wavelength you're trying to shield. Sounds tend to wrap around the edges, like an eddy created by water flowing around a rock.

3. Is masking brought on by competing frequencies?
    A. The answer is complex. We're now listening at the most basic level, recording everything equally from all directions. For example, at a loud party a person can hear someone say their name from across the room (cocktail party effect). It's unknown how adaptable belugas are to loud noise and likely belugas hear more than recorded by the EARs. Belugas have directional hearing and can orient toward certain sounds. Also need to factor in the relative proximity to the recorder/whale/noise source. It's unknown if belugas can shift tonal signals without losing content, as they do with clicking signals.
4. Is there a need to do work with captive animals to answer some of these questions?
    A. With focused questions, consider carefully what we need to know, experiments could be designed to measure beluga hearing.

Round Table Discussions HIMB

1. **Bill Lucey, Yakutat Salmon Board**
    A. Findings on Yakutat Belugas 2005-08
    B. Studies a very small beluga group (~10 belugas)
    C. 2008 field season
    D. Added acoustic data to prior data
    E. Three methods used
        i. T-PODs
            1) Detects beluga click trains in pre-determined frequency bands (30-50 kHz, 70-92 kHz, and 70 kHz-113 kH)
            2) Could program to record on multiple frequencies that would detect different species (i.e., belugas, killer whales, others)
            3) Yakutat belugas visit different area at different times, but don't necessarily visit the bay each day
            4) Different click rates suggest different uses in the different habitats
            5) Most dolphin species use a click "blast" when hunting/foraging
            6) No click relationship between click detections and tides
        ii. EARs
            1) Records time series data from 0-32 kHz
            2) Good for tonal calls but measures too low for the high frequency in echolocation
            3) Recordings made 5 minutes on recording and 8 minutes off recording, 24 hours a day
        iii. Dipping hydrophones
            1) Used opportunistically

2) One hydrophone was used and it was hard to tell what was going on

F. Conclusions

G. Results are preliminary

H. Disenchantment Bay, Yakutat is much less dynamic than Cook Inlet, therefore, different recording methods may work better in one place than another

I. TPODs proved useful to record beluga presence and absence, as well as a habitat use study in Disenchantment Bay

J. Recommend collaborating with Cook Inlet acoustics to examine the possibility of geographic variation in acoustic repertoire between the two beluga populations

K. Questions

i. How deep is Beluga Bay?

1) 50 fathoms deep, up to the shelf at 4-5 fathoms. Belugas like to work the edge.

2) In front of Hubbard Glacier its up to 100 fathoms deep

ii. How deep did you deploy the T-PODs?

1) Used a Danforth anchor to a trolling lead and suspended T-POD from that system

iii. What are the major food resources, besides salmon?

1) Shrimp, tom cod, saffron cod, herring, eulachon are in the Yakutat area, and varies from one location to another

iv. Would like to work with Auke Bay to do sonar studies in Yakutat (or does Bill mean, southeast?)

2. Leslie Cornick, Alaska Pacific University (APU)

A. APU has an undergraduate marine biology program, partially funded by At Sea Processors

B. New bio-acoustician on staff (Dr. Ana Sirovic)

i. Used passive acoustic triangulation method to measure abundance of fish in Antarctic

C. APU has a contract with Integrated Concepts and Research Corporation (ICRC) to monitor belugas at Cairn Point (Knik Arm). APU could have visual beluga data during EARs deployment at Port McKenzie

D. An APU graduate student (Lindsey Kendall) wants to do passive acoustic studies in Cook Inlet, specific to pile driving and belugas, regarding the Port of Anchorage expansion project

i. Hope to deploy acoustic recording devices in 2009, early August to mid September, when large beluga concentrations are observed near the port expansion footprint

ii. Possibly could expand the study's scope include Eagle River, if interest is there

3. Tamara McGuire, LGL Alaska Research Associates Inc.

A. Works on a photo ID study for CIBs and there are opportunities for visual collaboration on the EARs
B. Spent many days on the water while EARs were deployed in Aug 2008
C. Can also work with Defenders of Wildlife (Karla Dutton)
D. Coordinates with NMML so they are not on the water during the June and August surveys. Can provide beluga sighting information in areas and during dates the EARs were deployed.
E. Future efforts will depend on funds and their MMPA research permit, however, they plan to be on water mid-May to mid-October 2009
    i. They are looking for funds from National Fish and Wildlife Foundation and will likely have no funds by March without it
F. LGL would also like to help with genetic work underway
G. Possibility they could place a hydrophone in the water to document and record beluga vocal activity
H. Questions
    I. Is there a possibility of several CIB dialects or is the population too small?

    Rodd: First step is to look for subgroups within the Cook Inlet population, which can be done with more data

    Marc: belugas have a matriarchal social structure, which would serve as the basis for any dialects that might exist
        1. Suspect that groups may sporadically group/ungroup
        2. But a signature call may be identified

    Craig: seems there's a lot of mixing that goes on among these whales and I would doubt you'd find a dialect

4. Mike Williams, National Marine Fisheries Service

A. We deployed a couple recorders (bioacoustic probe), calibrated, autonomous hydrophones, at Cairn Point and Eagle Bay with visual observers
B. The aim was to look at how many acoustic observations visual observers missed and vice versa
C. Found a fair number of visual observations when belugas were very vocal and other times when were quiet
D. About 50 percent of time with working recorders and visual observers were both on site either the acoustics or the recorders missed whales
    i. Can we correct for this discrepancy and are we comfortable with making that correction?
E. Recorders were deployed at shallow spots and sometimes recorders were out of the water at low tide
F. They estimated average 1 km detection range
G. The key for future acoustic work will be finding deployment locations that cut back on vessel traffic

H. Questions
   i. Were beluga detections determined by calls or clicks?
      1) Visually reviewed sonagrams for both calls and clicks and beluga calls determined only presence or absence
      2) Frequency bandwidth wasn't great (maximum 8 kHz)
   ii. Was there interference with harbor seal recordings?
      1) There was no problem with harbor seals, the big problems were a) flow noise and b)) recorders out of the water at low tide
      2) Study found that belugas are typically at Cairn Point at high tide

5. Craig Matkin, Northern Gulf Oceanic Society

A. There was a pilot project on killer whales in lower CI, to see what kinds and how many killer whales were in the area
B. There were quite a few transient killer whales in 2008
C. Saw killer whales attack humpbacks and apparent evidence of killer whale predation on humpback carcasses
D. Not many belugas are in lower Cook Inlet
   i. Is this an issue?
   ii. Do killer whales prevent belugas from inhabiting lower Cook Inlet?
E. Would be great to have people power to document predation
F. Killer whale recordings were historically used to keep belugas out of river mouths during salmon runs
G. Need "Big Eyes" on a tripod to see more, but what is missed, there is the ability to photograph
H. Questions
   i. Is it worth it to program killer whale frequency ranges on the EAR when looking for CIBs?
      1) Probably not needed. Transient killer whales, most likely in upper Cook Inlet, are relatively quiet compared to resident killer whales, so the EAR would have trouble detecting and recording sounds
      2.) Most likely it would be possible to hear beluga kills, through bones crunching, but not much socialized vocals
      3) Predation in Cook Inlet occurs relatively infrequently
      4) Marc: Transients still echolocate. Even if it's just for navigation, it is infrequent and almost like depth sounding
      5) T-PODs could detect and record both killer whales and CIBs
      6) Frequency range is different for killer whales and CIBs, but a T-POD could be programmed to detect both
      7) Craig: Transients make "quiet calls"

8) Almost have to be right on top of them to detect them
9) Transient killer whales may echolocate more in new locations when it doesn't jeopardize their hunting

ii. Any estimate on beluga numbers in Kamishak Bay?

1) Craig: No estimate, no photos, just stories! Craig has never seen belugas in Kamishak.
2) One beluga was reported taken by killer whales (Deep Creek area), but it turned out to be a minke whale stripped of dark skin

iii. If calls are received of belugas and/or killer whales in Kamishak area, please call Craig

1) Craig works with Citizens Scientist Monitoring Program and the Cook Inlet Tug & Barge

6. Chris Garner, University of Colorado, Fort Richardson

A. Dual frequency identification sonar was developed for the Navy, operates at 1.2-1.8 MHz

B. Can actually "see" anything with clarity from 12-20m

i. The details you receive are pretty incredible

ii. It would be useful to correlate beluga numbers observed at the surface with numbers that are actually there

7. Chris Hoffman, Corps of Engineers (COE)

A. Port of Anchorage Dredging Project

B. COE will consider hydraulic suction dredge, not just the clam shell

C. COE has requested acoustical studies on hydraulic dredging

D. Dredge material is discharged in lower Knik Arm

E. Could some loud background noise from the EAR at Fire Island be dredged material?

i. Marc: one person's noise is another person's signal and he would have to analyze the "garbage" data

8. Round Table Wrap Up

What was learned in Cook Inlet during 2008?

A. Biggest take home message is that acoustic monitoring success depends on location

B. Working in noisy environments will be challenging with much to learn

C. Deployment methods: simple is better

D. Something should not be too expensive that you can afford to lose it and/or have multiple deployments

i. EARs cost ~$4,500

ii. EARs with an acoustic release costs ~$7,500 (release is $3,000)

E. Need to find a compromise with deployment length vs. cost

F. Add chains, shackles, and anchors can be very noisy on the recorder. The non-strumming cable used with ASLC EARs was ideal.

G. Armor coated line with strum resistance was used and it was very heavy duty but did not give much to stress
H. Non-strumming cable is a synthetic line, armor coated, and rated to 15,000 pounds (Puget Sound Rope/Portland Cable). It is a feathery line and can be made manually, like a whisper line
I. Cable can break down and be very noisy
J. A risk that data will be lost, especially on long deployments
K. Ideal scenario is when EARs and T-PODS are deployed to work together
    i. EARs record belugas calls
    ii. T-PODs will record clicks and you can determine that echolocating belugas are in the immediate area
        1) BUT if belugas are familiar with an area they may echolocate less
        2) If you put an EAR and a T-POD together (strung together?) it would improve your chances to detect nearby animals, even if they are quiet
        3) T-PODs may not give a very large (ie < 1km) recording range
        4) Most recording files on a T-POD will be directed toward the T-POD
        5) However, as T-PODs become common (part of the landscape), belugas may echolocate toward the T-POD less frequently; another good reason to pair T-PODs with an EARs.

Questions

1. Is it possible to download EAR data without pulling the unit up?
    i. No, data is collected by removing the EAR's hard drive at the surface. The EAR would have to be redesigned significantly to collect data from the ocean floor.
2. With 30+ foot tides in Cook Inlet, how can the unit be kept safe during low tide?
    i. Use geometry to adjust length of cable according with tides and select deployment site carefully
3. Is one field season that records up to 10 kHz enough to set a standard for future beluga detection attempts?
    i. The gain in bandwidths above 10 kHz is most likely minimal
        1) If the intent is to detect the presence or absence of belugas, a low frequency limit should be adequate
4. Is there a need to get the suite of CIB signals that can be used as a library to perfect detection algorithms?
    i. That will not be necessary. The best signal types to use as algorithms are those signals actually recorded on the EARs
    ii. A suite of CIB signal will be useful in understanding the CIB vocal repertoire.

Seasonality

1. In Knik Arm, beluga concentrations are highest in August through September
2. The problem is placing EARs at times and locations where beluga presence is unknown, less of a concern is confirming known beluga presence
    i. For example, to measure the effect on belugas from pile driving
3. From a management and small takes perspective, a year-round tally is needed to determine if the port expansion exceeds authorization
4. Beluga recordings can be used to determine beluga activity during different times of the year
    i. Do certain events (such as CIB movements) occur at the same time(s) each year?
5. People with different questions may look at the same data and see different things

Questions and comments

1. How can improving technology be calibrated so it matches the data taken in the past ('old' technology)?
    a. For example, Year One you record 30 seconds every 5 minutes, Year Two you record 1 min every 5 minutes, then you can calibrate data by ignoring the first 30 seconds of data in Year Two.
        i. This was a problem with many past acoustic studies because there is no basis for comparison
2. The need for real time monitoring
    a. Remote deployments challenge real time observations. May have a unit (both for a power source and communications) that is cabled back to shore since a surface deployment isn't practical
        i. Cabling remote deployments to land is expensive to deploy and maintain

Workshop Recommandations

1. General Recommendations

A. Coordinate on-the-water efforts to assist with ground-truthing activities and predation events (LGL, Army, Defenders of Wildlife, NGOS)
    a. Create an organized beluga sighting network
B. Keep mooring designs simple and combine EARs and PODs with the next generation PODs
    a. Select sites carefully, preferably away from shipping channels
    b. Particularly useful for long-term monitoring
C. Develop CIB Sighting Database that multiple agencies can access
D. Coordinate an acoustic project with multiple agencies to answer multiple acoustic questions

a. Deploy an array of acoustic equipment for longer time periods during the ice-free season
b. Acoustic detection study on belugas related to Incidental Harassment Authorizations

E. NOAA has guidelines on passive acoustics
F. Better document CIB movements and habitat use to help structure, calibrate, and validate acoustic studies.

2. Uses of Acoustic Technologies in CIB Research Management

(Note that the priority of these topics was only sometimes discussed. Where that priority was identified it was inserted in parenthesis)

A. Distribution and acoustics
   a. Map Cook Inlet acoustic environment by season and year to establish baseline noise level (High priority)
      i. Are there any baseline acoustic data on historical background noise in Cook Inlet?
         a. No historical acoustic data has been identified. Historical noise levels would be determined by looking at vessel traffic now and working backwards,
   b. Relate current acoustic environment to the past using correlates with human activities and natural changes in the inlet (High priority)
   c. Estimate CIB injury and interference risks from anthropogenic noise (High priority)
   d. Build acoustic curtain across the Forelands, the narrow place in Cook Inlet to possibly determine directional movement beluga and whether they are /belugas move to lower Cook Inlet.
B. Abundance Estimation
   a. Have EARs in place to record beluga sounds during surveys at the same time the aerial component would estimate size
      i. Aerial abundance surveys in June are short-term (9-12 days). An acoustic recorder in mid-inlet, between Kalgin Island and the Forelands could be useful to detect if belugas are present during surveys. This information would complement the aerial survey data. (High priority)
   b. Winter Movements: There is a huge data gap on CIB over-wintering information. Long-term recorder(s) strategically placed, including mid-inlet, would help better understand winter use
   c. Distribution list: Develop list to update beluga researchers on beluga sightings until real time data is available (Low priority, lack of real-time abilities)
   d. Aerial Surveys: Estimate CIB population abundance (?) and distribution in other months besides June
      i. Deploy acoustic arrays during survey periods

e. Video/Critter Cameras: Georeferenced areas where acoustic recorders can provide ground truthing
    i. Georeference images within 100m to help calibrate acoustic equipment
    ii. Complement images with aerial surveys, could do both at the same time
f. Relate acoustic behavior to surfacing behavior to improve abundance estimates
    i. Determine surface intervals for CIBs
    ii. Deploy acoustic arrays and observers
    iii. Correlate beluga behavior with vocalizations (i.e., calling rate)
g. Attach acoustic tags to belugas with Time-Depth-Recorders (Low priority, MMPA research permit)
    i. Put transducer on animal so EAR can detect presence or absence of whale in the vicinity of your EAR

C. Acoustically estimate age-structure (low priority, for immediate applications)
    a. Estimate calves from beluga calls peculiar to calves or adult-calf pairs
        i. Could determine nursery areas
        ii. Estimate ratio of juveniles to adults
    b. Difficult to identify specific sounds from specific animals unless you know the individual animals, thus not probable with a large group.
        i. Possibly identify signature whistles and identify them to specific animals
    c. Could complement photo identification work.
    d. Could work on captive animals
        i. Determine if there are characteristics that varies from young and old belugas
        ii. If peculiar calls can be patterned in captivity and later identified in the wild.

D. Extinction Risk Probabilities (High priority)
    a. Estimate beluga predation events
        i. Conduct in Chickaloon Bay or mouth of Cook Inlet along with visual observations if possible.
        ii. Predation occurrence may be low, but could be a prolonged event when it occurs
            a. This may have to be a byproduct of another study rather than a directed study
    b. Estimate beluga abundance and frequency in areas at risk of point source mortality events
        i. Good location for EAR deployments
        ii. Consider EAR deployments with the sewage outfall pipe and where oil spill has occurred

            a. Deploy recorders at Pt. Woronzof, Anchorage sewage outfall location
    c. Assess human impacts to the beluga acoustic environment
        i. Is beluga distribution further up the inlet to escape noise in mid to lower Cook Inlet?
        ii. Are their sound refuges? Where are they located?
        iii. Do EARS work in rivers?
            a. Could help determine beluga use in rivers
    d. Long-term monitoring on beluga distribution and how they may be impacted with future developments

E. Acoustics and feeding (High priority)
    a. Identify beluga feeding sounds
        i. Profile whale sounds when feeding and resting.
    b. Identify beluga presence in feeding areas
        i. Can help determine critical habitat
    c. Identify beluga prey sounds
        i. Listen to prey sounds in captivity at ASLC to characterize acoustic profiles to be applied in the field

F. Determine basic biology (Medium priority)
    a. Relate beluga biology to acoustics
        i. Correlate certain sounds with certain beluga behaviors
            a. Use small beluga groups in less turbid areas to establish baselines or guidelines on beluga behaviors to apply to CIBs
            b. Attach sensor to belugas to correlate vocalizations with behaviors
        ii. Place T-PODs and EARs in areas with high anthropogenic sound levels to avoid the possible masking of CIB sounds by anthropogenic sounds

G. Secure Funding
    a. NMFS could receive $1-2 million over next year or so for CIB research (probably Broad Area Announcements, RFPs, and/or competitive proposals)
    b. The Coastal Impact Assessment Program (CIAP) might be made available soon, largely driven by oil and gas exploration funds(~$105 million)
        i. Portion (~30 percent) will be available through boroughs
        ii. Portion to the state will be available on competitive grant basis (pre-proposals)

Future Research That May Support Acoustic Studies

- Aerial Surveys: Annually in June (Abundance) and August (Calf counts): Ongoing
  - Other months as needed.
- Abundance, Trends, Population models: Ongoing
- Habitat Use Analysis: Revised and updated in 2008: Ongoing.
- Biological sampling and stranding response: Ongoing
- Diet and prey availability: Ongoing at low level
  - Requires larger effort to develop prey library and blubber samples
- Movements and dive behavior
  - Last satellite tagging effort was in 2002
  - Would like to begin a new study in 2010-2012, to update results
  - Shore based observation, acoustic sampling (e.g. EARS), photo ID: Ongoing
- Population health assessment
  - Baseline data and methods being developed in Bristol Bay
  - Would like to assess CIBs 2010-2012.
- Population genetics: Ongoing
  - Would need increased effort to assess population structure.

Overall, the group felt it was valuable to have discussions in one place among researchers engaged in various studies on CIB to stimulate ideas and make information available, so that researchers could better coordination and collaboration.