Ceteacean Social Behavioral Response to Sonar

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LONG-TERM GOALS

The goal of this effort is to investigate cetacean social behavioral response to sonar signals.

OBJECTIVES

The scientific objectives of this effort are 1) to study social, group-level behavioral responses of cetaceans to sonar signals and other stimuli, including tagging; 2) to study natural, baseline social behavior of the cetaceans studied; 3) to develop quantitative, generic methods and protocols for the study of social, group-level behavior of cetaceans; 4) to develop methods to study behavioral responses of cetaceans to sonar signals in situations where tagging is not at present possible (tagless playbacks); 5) to facilitate in the integration of methods and data from different behavioral response studies.

APPROACH

Social, group-level cetacean behavioral responses to sonar signals and other stimuli (tagging effort, killer whale playbacks) as well as baseline behavior, are studied within the larger framework of controlled exposure experiments (CEEs) conducted as part of the 3S/3S^2 and SOCAL behavioral response studies (BRS) off Norway and California. Visual collection of cetacean social behavioral parameters takes place simultaneous with focal individual tracking and data-collection from suction-cup tags and towed hydrophone arrays. Additional baseline behavior of the studied cetaceans is obtained during dedicated baseline behavior research at the Azores (shore- and vessel-based), to allow for increased sample size and augmented understanding of natural behavior of the cetaceans studied, in relation to observed behavioral responses to stimuli.

Focal follow sampling protocols for visual sampling of cetacean group behavior were developed specifically for the use in this project. Specific requirements for the protocols included non-biased, systematic and generic collection of cetacean group behavior, providing quantitative, high quality data allowing for comparison across species, studies and areas. Generic properties of sampling protocols facilitating cross-comparison of data are deemed to be of special importance in BRS studies, conducted over a wide range of species and areas, and often characterized by relatively limited sample sizes.

In cooperation with the SOCAL-BRS project, the performance of group-level focal follow protocols for use in tagless playbacks is tested during dedicated research off California.

Data analysis specifically focuses on the integration between surface social behavior recorded by focal follows and group vocal behavior recorded by the suction-cup tags and towed hydrophone arrays, focal individual tracking and dive characteristics recorded by the suction-cup tags.

Key individuals
Patrick Miller (SMRU, Scotland), Peter Tyack (SMRU, Scotland), Frans-Peter Lam (TNO, the Netherlands) and Petter Kvadsheim (FFI, Norway) form the board of the 3S-project. Together with Hans Slabbekoorn, associate professor at the Behavioural Biology Group of Leiden University, the Netherlands, they act as main scientific advisors in this project. Brandon Southall (SEA.inc), PI of the SOCAL-BRS project, has a main role in the design and execution of tagless playbacks and cross-study implementation of group sampling methods in BRS.

WORK COMPLETED

- Continued development of protocol for group behavior sampling of social cetaceans
  - Status: operational (Visser et al. 2011)
  - Tailored version operational for baleen whale social and surface behavior
- Field-work
  - Participation in $3S^2$ and Socal-BRS field studies (June 2012; October 2012)
  - Lead Azores-Baseline field study (July-August 2012)
  - Field study and data-collection ongoing: field season two of three
- Social behavioral response data-collection in behavioral response studies (year 2)
  - Response to tagging, sonar and killer whale sounds exposure in $3S^2$
  - Response to tagging and vessel noise exposure in Azores-Baseline
  - Response to tagging and sonar exposure in SOCAL-BRS
  - Data collected for: humpback whale, minke whale, Risso's dolphin, short-finned pilot whale, killer whale
- Baseline social behavioral data-collection (year 2)
  - $3S^2$, Azores-Baseline and Socal-BRS field studies
  - Data collected for: humpback whale, minke whale, Risso's dolphin, N bottlenose whale, short-finned pilot whale, killer whale
- Development and testing of protocols for tagless playbacks
  - Status: development, testing and evaluation in Socal-BRS
  - Data collected for: long-beaked common dolphin, killer whale
- Cross-study implementation of group sampling methodology
  - Protocols used in 4 BRS studies in 2012: $3S^2$, Socal-BRS, Azores-Baseline and BRS-Med
  - Participation in MOCHA project workshops and -meetings
  - Cooperation with other projects: protocol discussed for use in BRS-Hatteras project, protocol applied in St Lawrence baleen whale behavior project
  - Training of social behavior observers for SOCAL-BRS

- Project presentations
  - Presentation of project results at the 2012 Biennial Conference of the Society for Marine Mammalogy in Tampa, Florida
  - Presentation of project results at the BRS-workshop during the 2012 Biennial Conference of the Society for Marine Mammalogy in Tampa, Florida and MOCHA-meeting in St Andrews, Feb 2012.

RESULTS

- *Operational protocol for group sampling of cetaceans*
  In 2011 and 2012, the social behavior sampling protocol developed in 3S was tested on a selection of new species, in new areas and by several different projects. It was found that the protocol is widely applicable to cetacean species forming relatively stable, small-medium sized groups (<30), and can be applied to new conditions without significant changes to the set-up. The project has resulted in an operational generic and quantitative group sampling protocol, enabling the comparison of data across (BRS) studies. Additional added value of the protocol was found in the recording of surface behaviors for species which typically spend longer times at or near the surface, including when foraging, potentially limiting the capability of the tag to differentiate between behavioral states. The protocol has to date been used to record short- and long-finned pilot whale, Risso's dolphin, killer whale, sperm whale, Northern bottlenose whale, Sowerby's beaked whale, humpback whale, fin whale, and minke whale social and/or surface behavior in waters off Norway, Spitsbergen, the Azores, California and in the Mediterranean Sea and the Gulf of St Lawrence. The protocol has been published as part of the 3S-2011 cruise report (open-access) (Visser et al. 2011) and is currently being prepared for publication in a peer-reviewed journal.

- *Cetacean social behavioral response and natural behavior*
  During the 3S cruises in 2011 and 2012, humpback whale social behavior was collected during 13 controlled exposure experiments (sonar exposure and/or silent control) during a total of 18 focal follow observations. Of these focal follows, 12, including 7 CEEs, were conducted in 2012. In addition to behavior during sonar exposure, data collection included phases of baseline behavior, tagging effort and killer whale playbacks (Fig. 1). Social behavior was collected simultaneously with the track of the focal whale and vocalization and dive characteristics as recorded by Dtags (after tag on). This rich dataset allows for multi-disciplinary analysis of natural patterns of social behavior and social behavioral response to sonar and other stimuli of humpback whales, using behavioral metrics from the different data-streams. Analysis is currently in progress.

  A second multi-disciplinary dataset, additionally including shore-based tracking and social behavior data collection, was collected for Risso's dolphin during the Azores-Baseline 2012 field project (Figs. 2 and 3). This dataset allows for analysis of Risso's dolphin natural behavior and tagging and vessel noise behavioral response using behavioral metrics from the different data-streams. The 2012 field effort resulted in the first Dtag attachments to Risso's dolphin in the Azores (Fig. 2). Two tags were deployed, for 15 and 37 minutes respectively. The added data stream of shore-based data allows for extended investigation of baseline behavior, without any vessels present near the focal whales (Fig. 2), and potential for the collection of larger datasets. In 2012, data was collected from 32 focal groups for a total duration of 61 hours. In addition, as protocols and data-collection procedures are comparable between the two BRS efforts, Risso's dolphin behavioral patterns and stimulus-responses off the Azores (Azores-Baseline effort) can be

compared to behavioral patterns recorded off California, as part of the Socal-BRS project. Behavioral analysis is currently in progress.

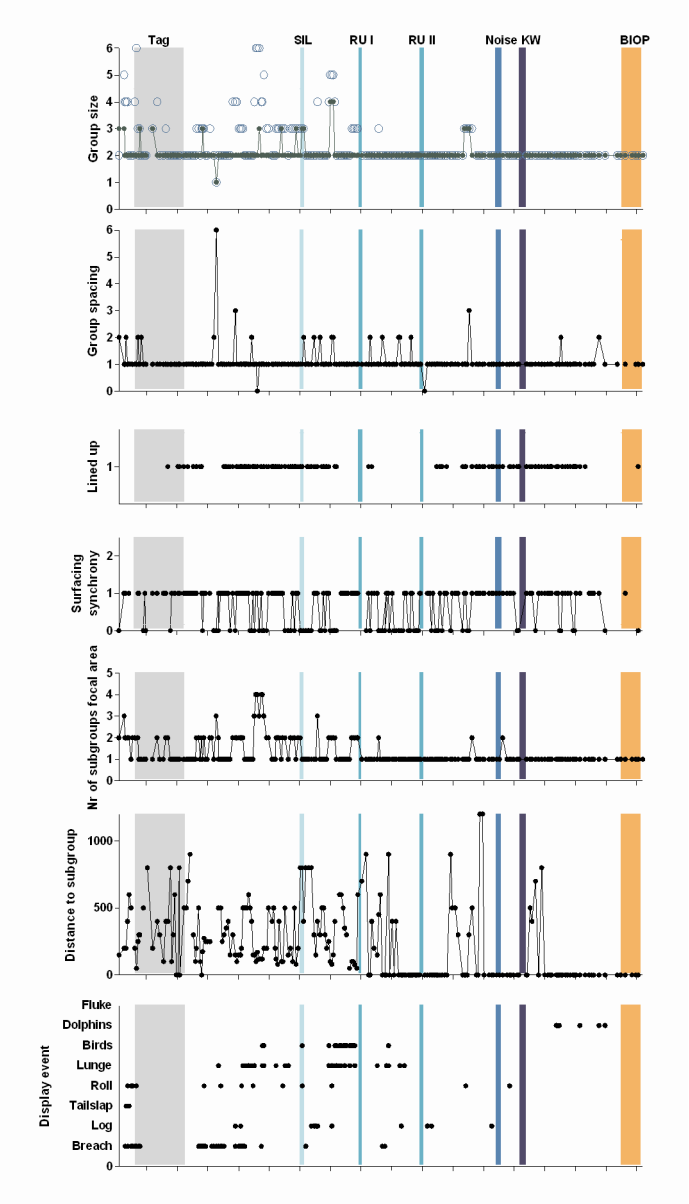

Figure 1. Example of humpback whale social behavior data collected June 29, 2012 during 3S2-12. The 17-hour experiment time-line consecutively shows tagging (gray), baseline (white), exposure (silent ramp-up, ramp-up I, ramp-up II, noise and killer whale playbacks (various shades of blue)) and biopsy sampling (orange) phases.

- *Development and testing of tagless playback protocols*
  Tagless playback protocols were designed specifically for species for which it is currently not possible to deploy a tag for longer durations, but which generally occur in high densities (high probability of being exposed to sonar): pelagic *Delphinids* such as common and bottlenose dolphins. The size and fluid nature of groups of these species require a different protocol than is used for the previously studied species. The structural difference is that it is not possible to select a focal individual and its associated focal (sub)group for the duration of the follow; the entire group

needs to be included in sampling. Methods for optimal conduct of tagless playbacks are being evaluated. Main limiting conditions for tagless focal follows are sea state >Bft 2, swell >1-2 m and high group spread. In addition, strong variation in directionality and speed can result in limited tracking capability, particularly from a stationary research vessel. A main result from the evaluation on-site was the added value of incorporating acoustic data from sono buoys, tags or hydrophones. Raw field analysis indicated alterations in vocalization patterns (clicks-trains and whistles) simultaneous with observed changes in behavioral states. Continued evaluation effort will include exploration of alternative methodology, for example including shore-based tracking.

Data-collection currently is an ongoing process for all species sampled, and will be continued during fieldwork efforts in 2013.

Figure 2. First documentend tagging attempt (left) and tag attachment (right) on Risso's dolphin at the Azores.

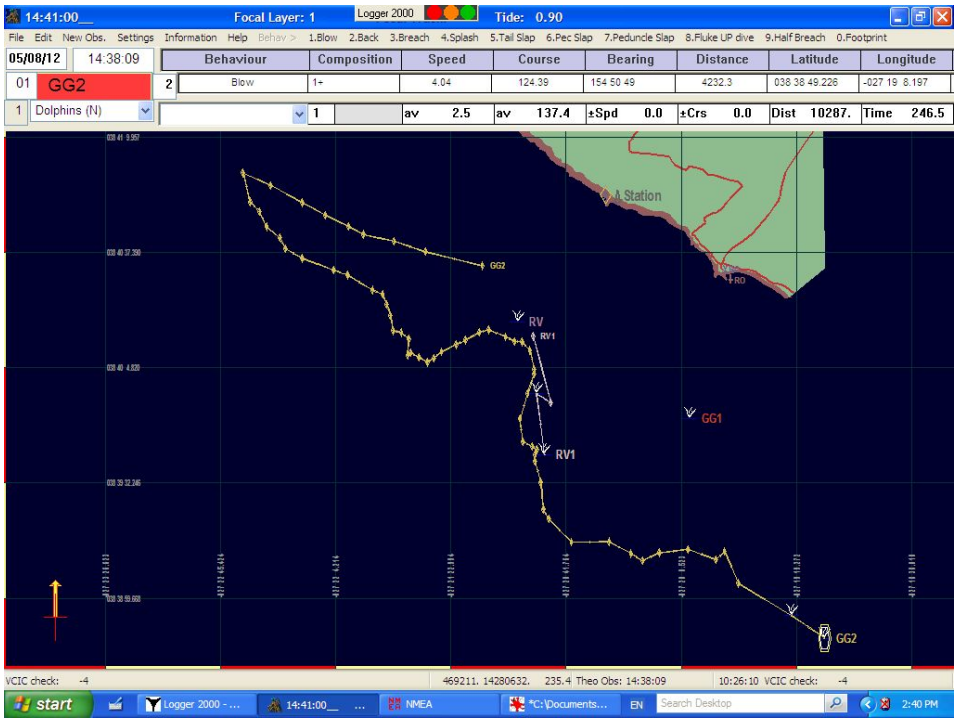

Figure 3. Example of shore-based tracking of Risso's dolphin: Vadar screenshot showing 3-hour shore-based focal follow effort of Risso's dolphin (yellow line 'GG2') off Terceira on August 5th, using a theodolite to accurately determine geographical location. Station = lookout, GGI = sighting of other Risso's dolphin group, RVI = Research vessel.

- *Cooperation with different BRS research projects*
  Exchange of methods and knowledge between BRS research projects in the field was deemed highly valuable, strongly facilitating the implementation and exchange of different methods both ways, and cooperation in data analysis. Exchange of scientists between the 3S/Azores-Baseline and SOCAL-BRS project took place in 2012, as well as coordinated discussions on protocols with members of the BRS-Hatteras project. The use of the operational protocols in different BRS projects facilitates future cross-comparison and potential joint analysis of BRS data.

IMPACT/APPLICATIONS

Social behavior of cetaceans, and social responses to changes in their environment form an essential element in our understanding of the complex nature of cetacean behavioral response to sonar. The generic nature of the methods and protocols developed in this effort can facilitate future cross-comparison of data between BRS projects, species and areas. It also may serve as a tool to extend BRS methodology to include species for which tagging methodology currently is not available.

RELATED PROJECTS

3S Project. A substantial part of this work is and has been executed as an integral part of the 3S project, in close cooperation with the 3S research team. Group sampling methodology for BRS as described here was developed within the 3S project and is now continuing in $3S^2$. ONR Award number: N000141010355

Socal-BRS. Cooperation in the development and execution of tagless playbacks and group sampling methodology in BRS. Socal-12 project website: http://sea-inc.net/socal-brs/socal-12/

Azores' Beaked whale project: Cooperation in tagging and tracking effort of target species in the Azores. ONR Award number: N000141210897

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