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Distribution and feeding ecology of dolphins along the Mid-Atlantic Ridge between Iceland and the Azores

L. Doksæter[a,b,*], E. Olsen[b], L. Nøttestad[b], A. Fernö[a,b]

[a]Department of Biology, University of Bergen, Thormøhlensgt. 55, N-5020 Bergen, Norway
[b]Institute of Marine Research, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway

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Abstract

During Leg 1 of the MAR-ECO expedition on the R.V. *G.O. Sars* in June 2004 four main species of dolphins were observed along the Mid-Atlantic Ridge from Iceland to the Azores: pilot whale (*Globicephala melas*) ($n = 326$), short-beaked common dolphin (*Delphinus delphis*) ($n = 273$), white-sided dolphin (*Lagenorhynchus acutus*) ($n = 103$), and striped dolphin (*Stenella coeruleoalba*) ($n = 86$). Pilot whales and white-sided dolphins were found in cold (5–16 °C) and less-saline (34.6–35.8‰) water masses in the northern part of the study area, whereas common and striped dolphins inhabited warmer (12–22 °C) and more-saline (34.8–36.7‰) waters in the south. Dolphins tended to aggregate in areas of steep slopes, but actual bottom depth appeared to be less important. Based on spatial correlations between dolphin occurrence and candidate prey organisms recorded acoustically and by midwater trawling, mesopelagic fishes and squids were assumed to be important prey items, with *Benthosema glaciale* probably being the most important prey for pilot whales and white-sided dolphins, while *Lampanyctus macdonaldi*, *Stomias boa ferox* and *Chauliodus sloani* were probably of particular importance for common dolphins. Cephalopods, especially *Gonatus* sp. and *Teuthowenia megalops* were the most likely prey species of pilot whales and striped dolphins, respectively. The difference in physical habitat north and south of the Sub-polar Frontal Zone seemed to have important effects on prey distribution, in turn influencing dolphin distribution.

Keywords: Mid-Atlantic Ridge; Dolphins; Physical habitat; Prey distribution

1. Introduction

Earlier studies of dolphins and their distribution and ecology were mostly limited to coastal ecosystems, and oceanic dolphins inhabiting the North Atlantic were rarely studied. Since distribution and ecology of dolphins is affected by several abiotic and biotic factors (Canadas et al., 2002; Yen et al., 2004; Tynan et al., 2005), ecological field studies of dolphins become challenging. The task is to observe and count dolphins while simultaneously measuring physical variables and plankton and fish abundance at relevant spatial and temporal scales (Croll et al., 2005). Pelagic animals often have distribution barriers that coincide with changes in the physical and chemical properties of the waters they inhabit (e.g., Jahn and Backus, 1975), and this also appears to be the case for cetaceans (Croll et al., 2005).

Different dolphin species often tend to prefer specific water masses characterized by temperature and salinity (Fullard et al., 2000; Reilly and Fiedler, 1994; Forcada, 2002), and their distribution is usually related to water depth, with individual species being associated with either oceanic or shelf waters (Davis et al., 1998; Weir et al., 2001; Canadas et al., 2002). Dolphins seem to show a greater affinity for steep slopes rather than flat bottoms (Hui, 1979 1985; Selzer and Payne, 1988). Physical parameters such as temperature and depth may affect dolphin distribution either directly or indirectly, and may reflect prey distributions (Selzer and Payne, 1988; Davis et al., 2002). Dolphins are endothermal and highly mobile animals and are thus

*Corresponding author. Department of Biology, University of Bergen, Thormøhlensgt. 55, N-5020 Bergen, Norway.
E-mail addresses: lise.doksater@student.uib.no (L. Doksæter), erik.olsen@imr.no (E. Olsen), leif.noettestad@imr.no (L. Nøttestad), anders.ferno@bio.uib.no (A. Fernö).

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not physiologically restricted to specific areas, yet they appear to inhabit species-specific physical habitats. Maintaining an internal body temperature higher than the environment requires a high metabolic rate, and in combination with a large body size, this means that dolphins need to consume large amounts of food. Prey abundance and distribution may thus be more important than the physical environment in regulating dolphin distribution. As a hypothesis, we suggest that mid-ocean dolphins are restricted to specific physical habitats, but that this is causally linked to prey distribution rather than the physical parameters of the habitats.

Direct observations of dolphins foraging at sea are difficult to obtain (Gannon et al., 1997). However, information on foraging ecology can be inferred by comparing abundance of prey items in an area to prior knowledge on prey preferences and diving capabilities of the dolphin species in question. The diet of oceanic dolphins has mostly been studied in the North Pacific (Chou et al., 1995; Ohizumi et al., 1998; Fiedler et al., 1998) and much less in the North Atlantic (Ringelstein et al., 2006; Pusineri et al., 2007). All these investigations indicate that mesopelagic fish and squids are important prey items for oceanic dolphins.

This study focuses on the four dolphin species most frequently observed during the MAR-ECO expedition along the Mid-Atlantic Ridge (MAR) between Iceland and the Azores in summer 2004 (de Lange Wenneck et al., 2008): short-beaked common dolphin (*Delphinus delphis*, Linnaeus, 1758), long/short-finned pilot whale (*Globicephala melas/macrorhynchus*, Traill, 1809, Gray, 1846), Atlantic white-sided dolphin (*Lagenorhynchus acutus*, Gray, 1828), and striped dolphin (*Stenella coeruleoalba*, Meyen, 1833). The primary objective of this study was to link dolphin occurrence and abundance to recordings of temperature, salinity, depth and bottom slope in order to analyze their patterns of occurrence in relation to the abiotic environment. Secondly we aimed to identify possible prey of the dolphins from acoustic data and midwater trawl samples, thereby providing information on their trophic roles in the pelagic food web of the Mid-Atlantic waters.

2. Materials and methods

2.1. Observation and sampling methods

Visual observations of marine mammals were made on Leg 1 of the MAR-ECO expedition, 5 June–3 July 2004 (de Lange Wenneck et al., 2008), from an observation platform on the roof of the wheelhouse of R.V. *G. O. Sars*, about 15.5 m above sea level. Observations were made in daylight only, mostly between about 0700 and 2300 h. Sighting conditions were considered suitable in sea states of Beaufort 4 or less, and observations were performed when in transit between the predetermined stations spanning the entire study area (station lists are given in de Lange Wenneck et al., 2008). Observations were made by naked eye and binoculars, and documented by video and still cameras for species identification and determination of group size. Marine mammals were identified to the lowest possible taxonomic level on the basis of published descriptions (Jefferson et al., 1994; Carwardine, 1995; Perrin et al., 2002). Observations of dolphins were linked to physical and biological variables collected continuously along the ship's track and at predetermined stations (Søiland et al., 2008; de Lange Wenneck et al., 2008). Sighting information and environmental data were recorded throughout the survey on a laptop computer connected to the ship's navigational (GPS) system. Data on near-surface temperature, salinity and fluorescence were collected by the ship's thermosalinograph, and bottom depth was recorded by the Simrad EK 60 echosounder.

Hydroacoustic data on sound-scattering biota in the water column also was recorded by the SIMRAD EK 60 echosounder, transmitting at five frequencies (18, 38, 70, 120 and 200 kHz). The choice of operating frequency is always a compromise between good target resolution (best at high frequencies) and long range (best at low frequencies) (Simmonds and MacLennan, 2005). This study focused on functional groups and aggregated layers of fish, thus reducing the importance of high resolution. Mesopelagic fishes might be found at depths of >1000 m during the day when the acoustic data used were recorded, thereby increasing the importance of longer range. Hence, the 18 kHz transducer will be better than the 38 kHz transducer mostly used in epipelagic fish studies (as also concluded in Opdal et al., 2008). The 18 kHz data were therefore used for the acoustic analyzes in this study. As explained in Opdal et al. (2008), area backscattering strength values were assigned to six scattering layers (Opdal et al., 2008, their Fig. 2). These layers were not determined from sampling by trawls, but from their characteristic vertical distribution patterns observed on the echograms. Layer 1 occurred within the surface layer, and mostly represented mesozooplankton. Layers 2–5 mostly contained mesopelagic fish at various depths, and Layer 6, the bottom layer, mostly contained demersal fish species. Only Layers 1–4 were used in our analyzes. Organisms from these layers would most likely represent the major prey species for the dolphins observed in the study area. The layering was clearest during the day, but more difficult or impossible to discern as the mesopelagic community migrated towards the surface at night. However, as dolphin observations were made during the day only, and the acoustic values used were restricted to observation intervals within a 5 nautical mile (nmi) distance of the dolphin observations, the merging of layers at night was not a major problem in this particular analysis. The data used in the acoustic analyzes are given in Table 1.

Fish samples used in the present analyzes were collected with a medium-sized pelagic fish trawl (Åkratrål). The trawl and its operations have been described by de Lange