Moving in Concert: Social and Migratory Behaviour of Dolphins and Whales in the North Atlantic Ocean

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Summary and Conclusions

Marine mammals have developed numerous behavioural adaptations to life in the ocean. Studying these behaviours, however, can be challenging. Cetaceans spend a large part of their life under water, are often difficult to find across the vast ocean, and their behaviour may change in response to the presence of the observer. Hence, many fundamental aspects of cetacean behaviour remain unknown. This thesis combines newly developed observational methods and recent advances in technology to study cetacean behaviour. This approach allows for investigation of the social context of individual behaviour and analysis of migratory behaviour in relation to large-scale ocean dynamics. The results shed new light on social foraging strategies and social organisation of deep-diving cetaceans and on the foraging behaviour of migratory baleen whales in the North Atlantic Ocean.

In **Chapter 2** we identify the social context of individual foraging behaviour in long-finned pilot whales (*Globicephala melas*). We use novel methodology, which combines concurrent recordings of social and diving behaviour, centred around one tagged individual. Long-finned pilot whales forage during deep dives, up to 800 m depth, during which they may become dispersed far from their group members. This is in sharp contrast to their surface behaviour, during which they preferably remain within 3 body lengths of each other. Our results show that groups of 5-15 long-finned pilot whales coordinate the timing of their foraging activity. This indicates that the species employs a social foraging strategy, which might benefit group members by signalling of good feeding opportunities.

In **Chapter 3**, we find that long-finned pilot whales strongly increase their vocal activity during the foraging periods, most notably for echolocation clicks and buzzes, indicative of prey detection and capture attempts. In addition, higher numbers of complex social whistles during deep dives suggests intensified and more complex social communication during foraging. Interestingly, the pilot whales strongly reduce their vocal activity in larger, more closely spaced groups, indicating that higher levels of social cohesion may release the function of vocalising. This confirms the overarching functionality of vocalisations to maintain group cohesion and to coordinate joint activities, as found across a wide range of social cetaceans.

Chapter 4 reveals a new form of social organisation in deep-diving cetaceans. Male Risso's dolphins (*Grampus griseus*) form long-term stable groups (clusters) of 3 to 11 individuals. The strongly associated males coordinate their behaviour, and may cooperate in foraging, mating and habitat defence. Females also form stable groups, but predominantly when they have nursing calves. This contrasts with the social structure of other species of deep divers, such as pilot whales, which is based on matrilines. Risso's dolphin social organisation thereby shows that deep-water foraging does not necessarily require the formation of long-term stable matrilines, but confirms the need for deep-diving odontocetes to provide alloparental care for dependent young during foraging activity. **Chapter 5** studies the behavioural responses of Risso's dolphins to increasing intensities of whale-watching activities. During the high season of

whale watching, in summer, Risso's dolphins rested and socialised less, and shifted their resting activity to periods with fewer vessels. These results suggest that disturbances from vessel noise and close vessel approaches may mask the exchange of vocalisations, or affect social cohesion, with potential negative effects for the energy budget of Risso's dolphins.

In **Chapter 6** we show that baleen whales forage on northern krill at the Azores during their spring migration towards higher latitudes. Hence, our results demonstrate for the first time that the Azores is an important mid-latitude foraging area during spring. This has strong implications for our understanding of their energy budget, as baleen whales were thought to fast during migration. Our results show that the timing of their migration follows the timing of the onset of the North Atlantic spring bloom. As the phytoplankton spring bloom propagates from south to north over the North Atlantic Ocean, it generates ideal growth conditions for northern krill. Hence, it may be that baleen whales track the spring bloom along its entire trajectory. As the spring bloom is sensitive to changes in climate, in particular to the warming of ocean surface waters, global warming may also have implications for the trajectory of baleen whale migrations and their ability to find food *en route*.

In conclusion, the results reported in this thesis demonstrate that the combination of classical observational approaches with automated sensors developed for tagging and remote sensing can shed new light on the social and migratory behaviour of dolphins and whales. The new knowledge gained from such advanced monitoring approaches is not only of fundamental interest, but may also be of considerable value to mitigate negative effects of anthropogenic disturbances on these magnificent animals.