

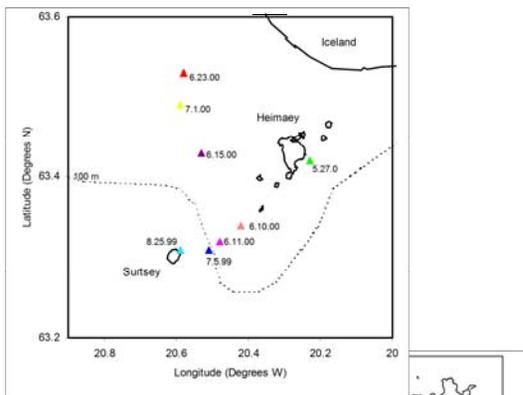
# DIVING BEHAVIOR OF FISH-EATING KILLER WHALES OFF SOUTHERN ICELAND

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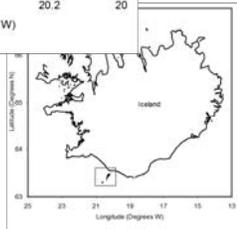
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## DIVING BEHAVIOR AND PREY ACTIVITY

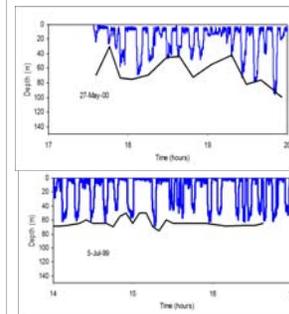
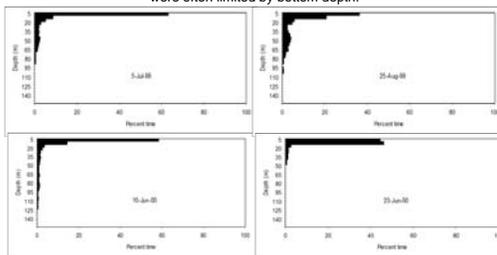
Sub-surface behavior of odontocetes should be driven primarily by their ecology – what they do in the water column should depend largely on the depth and behavior of their prey. Studies examining diving of individuals of more than one population of a species provide a strong comparative opportunity to examine the selective forces influencing sub-surface behavior. For killer whales, we hypothesize that different prey types (e.g., herring or salmon) should influence dive depths and durations, since herring are primarily schooling prey, while salmon are primarily “single” prey. Diving behavior of herring-eating killer whales was studied off Vestmannaeyjar, on the southern coast of Iceland, in the summers of 1999 and 2000, using suction-cup attached time-depth recorder/VHF radio tags. Eight tags were deployed for periods ranging from 8 to 44 hours, providing a total of 213 hours of dive data (average deployment 26.7 hours). While killer whales off Iceland foraged in waters ranging in depth from about 30 to 150 m in depth, they spent an average of 76% of their time in the top 10 m of the water column (range 57-96%). Average depth of dives >1 min in duration were to about 30 m, with average durations of just over 2 min (maximum duration 10 min). Dives to depths of 50-140 m, usually to or close to the bottom, were recorded for all individuals.



Study area off the southern coast of Iceland showing initial tagging locations



**Icelandic killer whales spent the majority of their time in the top 10 m of the water column,** though dives to deeper depths occurred regularly. The maximum depths attained were often limited by bottom depth.



**Dives to or close to the bottom were regularly recorded**

Locations of tagged whales were recorded every 10 minutes during 17 hours of follows, and bottom depths near tagged whales were obtained by interpolation off a nautical chart.

**Icelandic killer whales foraged closer to the surface at night, following herring movements.**

The Icelandic summer is characterized by extremely long days, with between 3.5 and 8.5 hours between sunset and sunrise (between May and August). During the “night-time” period it is still somewhat light out (there is continued nautical twilight all night). Herring, the only known prey of killer whales in the area, are known to spend the day near the bottom, and approach closer to the surface at night (Ferno et al. 1998).

We examined several parameters for dives > 1 minute in duration (two-tailed paired t-tests). Those which reflect overall activity levels (# dives/hour, velocity, ascent/descent rates) suggest that activity levels during the day and night are similar.

	Day Mean (SD)	Night Mean (SD)	Significance
Dives/hour	9.2 (2.16)	9.6 (3.70)	0.81
Duration (min)	2.4 (0.47)	1.8 (0.37)	<0.001
Depth (m)	32.8 (12.34)	15.6 (10.06)	0.01
Ascent rate (m/sec)	1.38 (0.37)	1.24 (0.38)	0.48
Descent rate (m/sec)	1.65 (0.33)	1.5 (0.42)	0.47
Velocity (index)	0.96 (0.47)	0.84 (0.31)	0.46

There were significant differences in dive depth and duration between day and night: during the night dives were both shallower and shorter. These differences likely reflect the movement of herring towards the surface at night.

**Prey-choice influences diving behavior**

Diving behavior of fish-eating “southern resident” killer whales was studied in southern British Columbia and in Washington state in 1996-1998. Icelandic killer whales feeding on herring are found deeper in the water column during the day. *Southern residents* tend to feed shallower in the water column, as their primary prey (salmon) are concentrated near the water’s surface, though they do also make occasional deep dives to the bottom. At night, *southern residents* spend more of their time engaged in rest behavior, with shallow, long duration dives, with a substantial proportion of their time spent at the bottom of dives. Icelandic killer whales spend their nights primarily engaged in shallow, shorter duration foraging dives, as herring rise closer to the surface. Prey-choice, even between small schooling versus large single fish prey, seems to influence diving behavior.

	Icelandic	“southern residents”	Significance
Depth day (m)	32.8	23.5	0.058
Depth night (m)	15.6	15.1	0.44
Duration day (min)	2.4	2.4	0.39
Duration night (min)	1.8	2.3	0.017
% bottom time day	38.8	37.7	0.72
% bottom time night	35.6	43.0	0.03

## Study area and population

The study was conducted between May and August of 1999 and 2000 around Vestmannaeyjar (the Westman Islands) off the southern coast of Iceland. The area is an important summer spawning ground for herring (Jakobsson and Stefansson 1999) and has a relatively shallow bottom depth (<150 meters). Killer whales (usually tens of individuals) are present in the study area on an almost daily basis during the summer months. In three years of photo-identification and behavioral work in the area approximately 100 individuals were documented. Individuals are frequently re-sighted, suggesting a somewhat resident population. The only killer whale feeding behavior documented in the area involved predation on herring.

## Methods

The tags we used are the same tags used in other several other studies of cetacean diving behavior (e.g., Baird et al. 2001), and consisted of a MK6 time-depth recorder (Wildlife Computers) and a VHF radio transmitter (Telonics) potted in syntactic foam, and attached with a suction cup. Tags weighed approximately 400 grams and were deployed using a crossbow. Depth (at 1 m accuracy) and velocity data were collected every second. Tagged animals were followed and observed for periods ranging from 19 minutes to 7 hours (total 17 hours). Location, behavior, and proximity to other animals were recorded every ten minutes.

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