Detection and Tracking of Whales Using a Ship-Borne, 360° Thermal Imaging System

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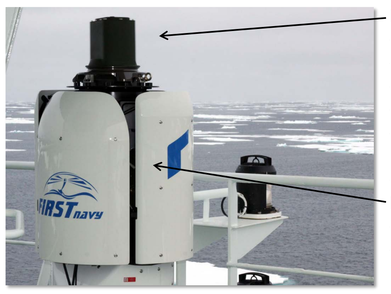
Motivation

Marine mammal observations

- Shut-down of under-water noise producing activities in the presence of whales is meanwhile a standard mitigation procedure required by many regulating agencies
- Determination of whale presence is thereby mostly based on visual sightings of the whale's blow by dedicated observers
- Visual sightings are restricted to daylight hours, require utmost concentration by observers and large teams when conducted during month-long cruises
- An automatic detection system with night-vision could support MMO's detection efforts

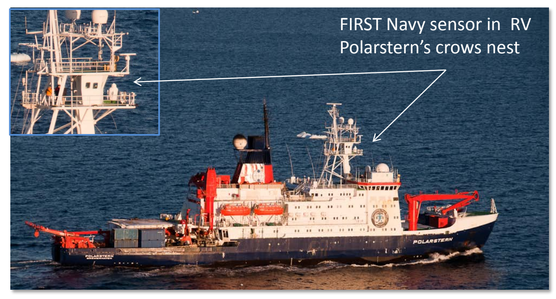
The MAPS Project

- Goal: Develop operational automatic detection system to assist mitigation and research
- Step 1: Generate and handle thermal image video stream
- Step 2: Develop real-time automatic detector for blow signatures
- Step 3: Determine system performance for different environmental conditions / species



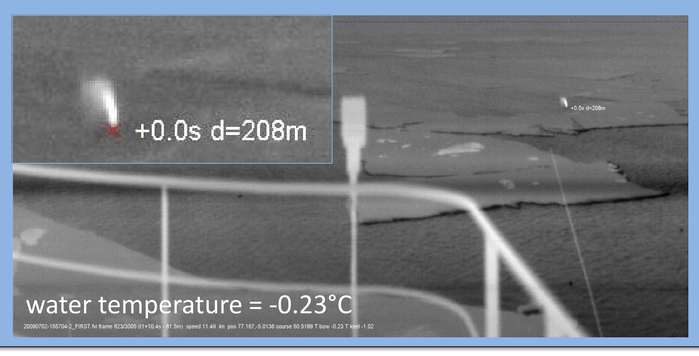
FIRST Navy IR thermal imager by RDE, Bremen
- Rotating, cooled (80°K) line sensor
- Field of view: 360° (horizontal) x 18°(vertical)
- Frame rate: 5 Hz (0.2s resolution)
- Thermal resolution: 0.0004°K
- Image resolution: 7200 (horizontal) x 576 (vertical) pixel
- Data rate: 3.5 Tbyte/day

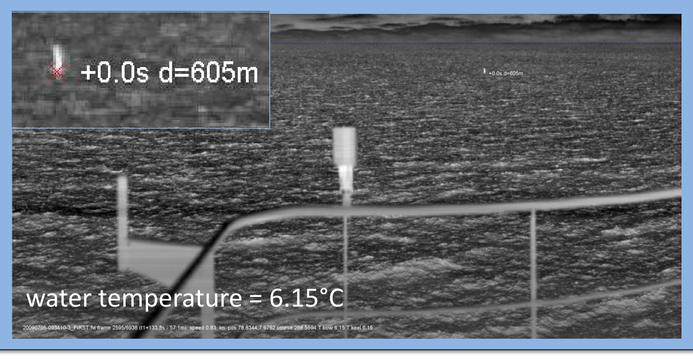
Fully stabilized platform (gimbal) (± 12° roll/pitch)
- Mounted in crow's nest, 29 m height
- Effective field of view: 300° (horizontal) from about 100 m from ship to horizon

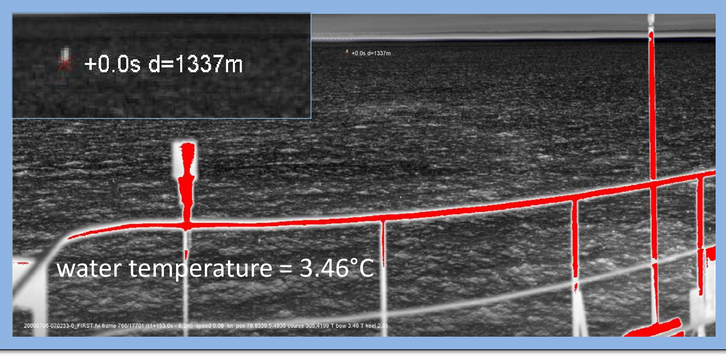


Detection

Thermal images provide clear signals of blows under varying (polar/subpolar) environmental conditions





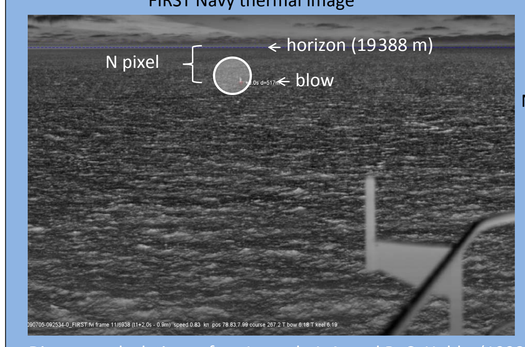


Tashtego software: Real-time display and event detection for MMO assistance

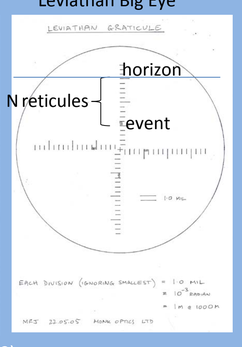
Trackings

Distance calculation

FIRST Navy thermal image



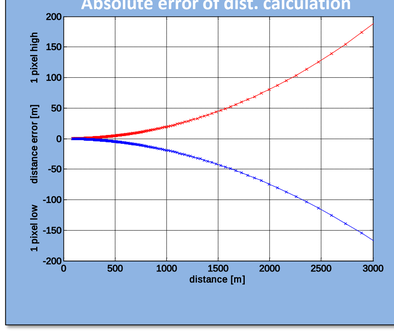
Leviathan Big Eye



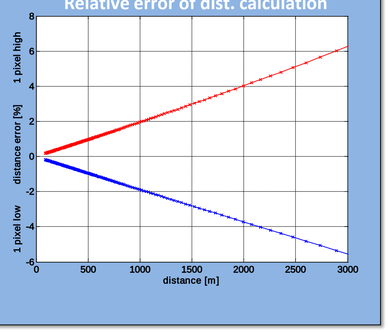
Distance calculations after Lerczak, J. A. and R. C. Hobbs (1998):
r = r (pixel between horizon and event, instrument height, resolution)

Type	Resolution (°/ reticule)	Field of view
very best cond. (Big Eye)	0.01°	
at sea	„…worse than 0.1°…“	
Fujinon 7 x 50	0.286°	10.0° x 10.0°
Fujinon 25 x 150	0.08°	2.7° x 2.7°
Leviathan	0.057°	2.6° x 2.6°
FIRST Navy	0.0313°	360.0° x 18.0°

Absolute error of dist. calculation



Relative error of dist. calculation

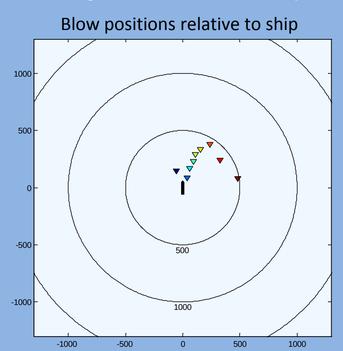


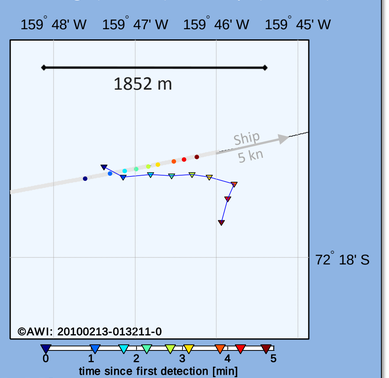
Examples of tracked whales

Minke Whale (2010-02-13)

Short track of a single minke whale crossing in front of ship's bow
Period analyzed: 01:31 – 01:38; First detection: 01:32:11; Last detection: 01:37:01
→ Relatively constant inter-blow interval throughout observations: 36 ± 13 s
→ change of swim direction and speed from "along" (2.2 ms^{-1}) to "away" (6.4 ms^{-1})

Blow positions relative to ship

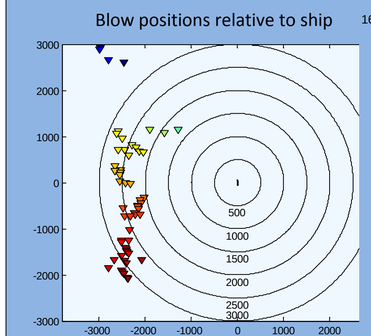


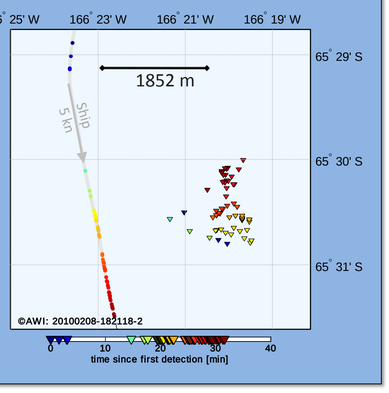


Humpback whales (2010-02-08)

A group of at least 3 humpback whales at 1 km to > 3 km distance
Period analyzed: 18:00 – 18:54; First detection: 18:21:18; Last detection: 18:52:53
→ Time between synchronized dives: about 10 min
→ Apparently prolonged period near surface (15 min) during ship's passage
→ No overt escape response

Blow positions relative to ship

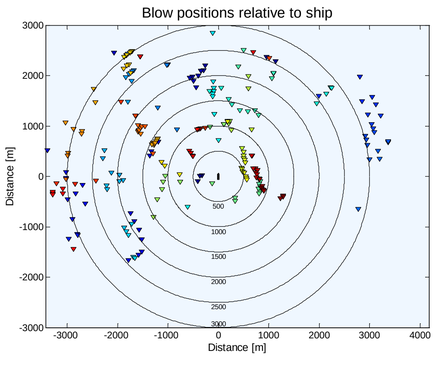


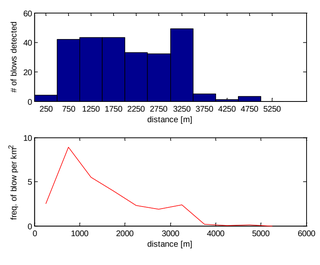


Results

- Proof of concept established
- Image quality excellent, both night and day
- Long term stability of image acquisition system (FIRST Navy sensor hardware) currently insufficient, debugging in progress
- Graphical user interface (Tashtego) operational
- 5 weeks (~837 hrs) operation in Greenland Sea and Southern Ocean
- 4.7 TB data archived for retrospective analysis and development of automatic pattern recognition algorithm
- ~500 blows detected by retrospective visual screening of IR video
- Blow detection in waters as warm as up to 10°C
- Polar detection range ≈3 km (< 6km)
- First automatic algorithm detects 19 of 20 blows

Blow positions relative to ship





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