Seiche
Marine Acoustic Solutions

Thermal Imaging
Round the Clock Visual Monitoring

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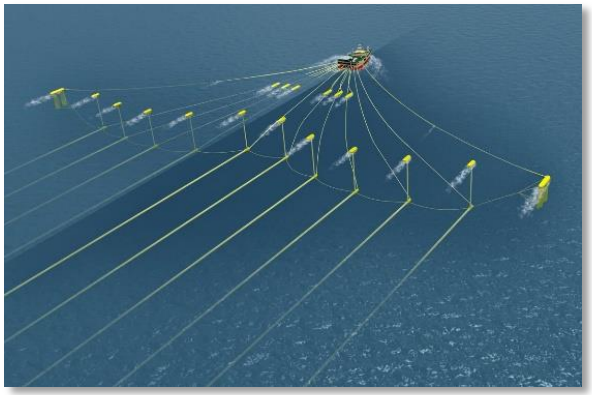
BOEM
Bureau of Ocean Energy Management

NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Content

- Commonly used low-light techniques
- Comparison of thermal and night vision
- Thermal imaging technology
- Camera visual monitoring solution
- Other applications
- Conclusion



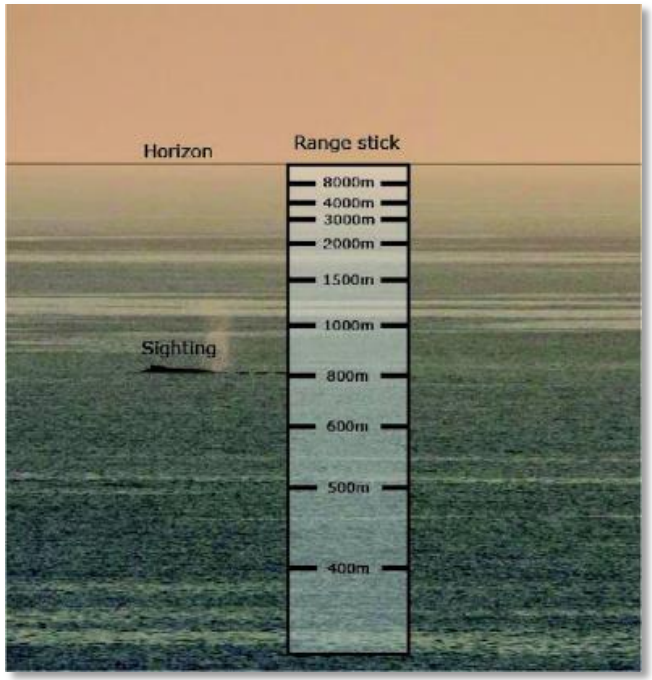
Commonly used low-light techniques

Marine Mammal Observer (MMO)
Protected Species Observer (PSO)

- Naked eye and binoculars
- Difficult to estimate distance accurately
- Health and safety risks

MMO on drilling rig standing alongside range stick

Todd, Victoria, et al. Marine mammal observer and passive acoustic monitoring handbook. Pelagic Publishing Ltd, 2015.



Example range stick

Todd, Victoria, et al. Marine mammal observer and passive acoustic monitoring handbook. Pelagic Publishing Ltd, 2015.

Night vision binoculars

- Works by amplifying low light, e.g. light from the moon
- Cannot work in total darkness
- Requires a spotlight in total darkness
- Can be improved with clip-on thermal imager

Thermal Illuminator

http://www.larsonelectronics.com/p-49576-infrared-led-handheld-spotlight-pistol-grip-spotlight-w-16-coil-cord-3-watt-730850nm940nm.aspx

Night vision binoculars

Clip-on thermal imager

http://www.nivisys.com/en/products/thermal_systems/tacs_m

Thermal imaging cameras

- Senses thermal (heat) radiation
- Works in total darkness
- Produces high contrast images

Thermal camera

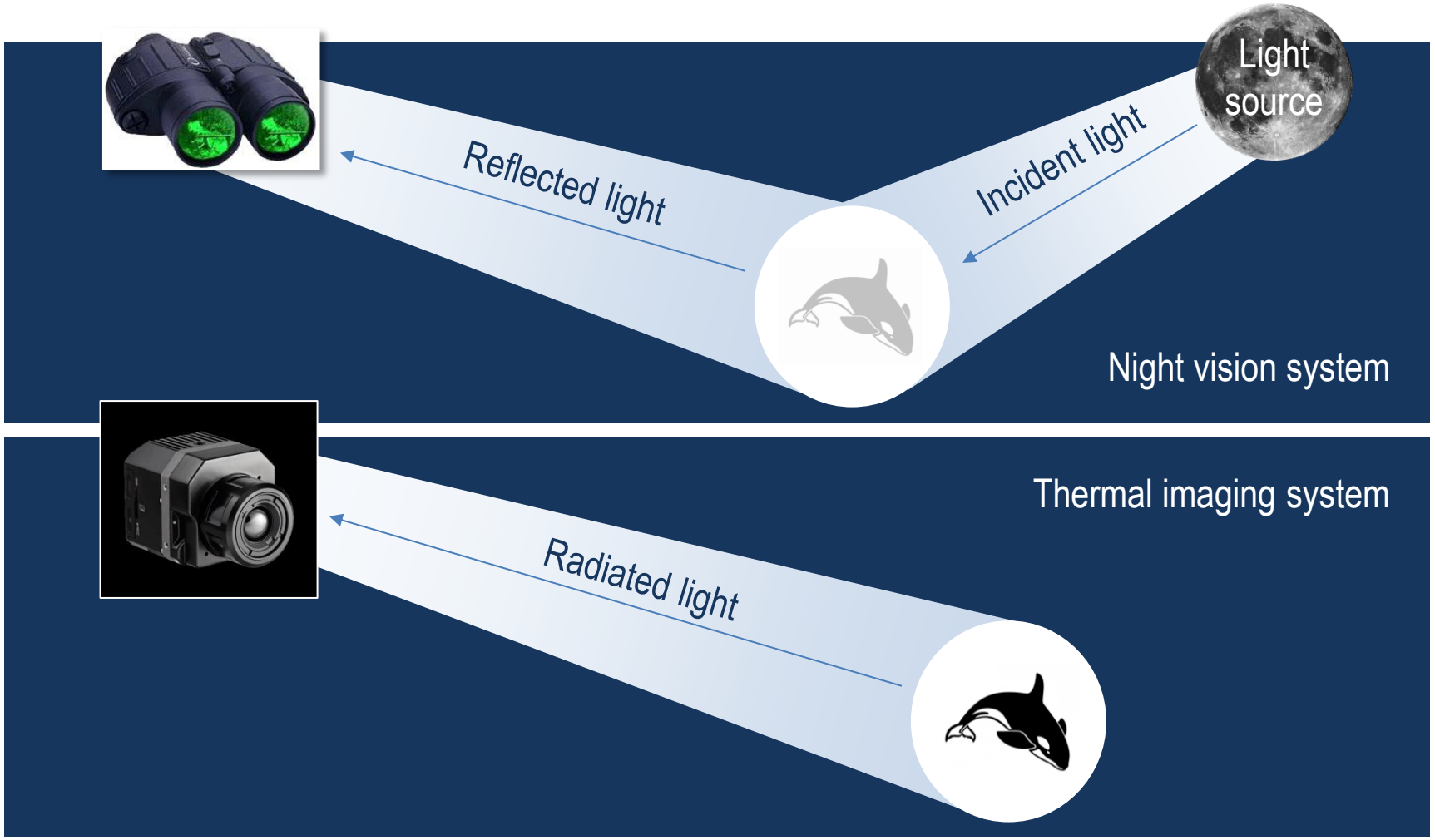
Thermal image of whale tail

Thermal binocular

Comparison of thermal and night vision

Thermal imaging vs night vision

- Schematic showing operation of night vision vs thermal imaging systems



Thermal imaging vs night vision

- Effective range of night vision is limited
  - Because it relies on the intensity of the light source
- Field of view may be limited compared to thermal
  - Due to narrow beam with of illuminator, only the area it covers is visible at that time
- Thermal image creates better contrast images
  - Can result in grainy images due to noise from amplification

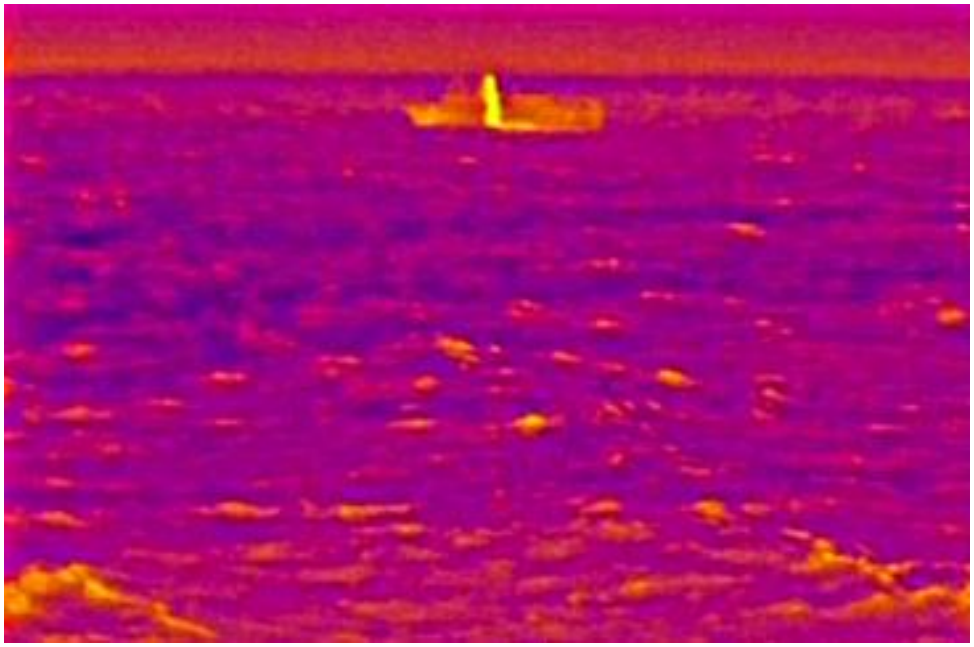
Thermal imaging vs night vision

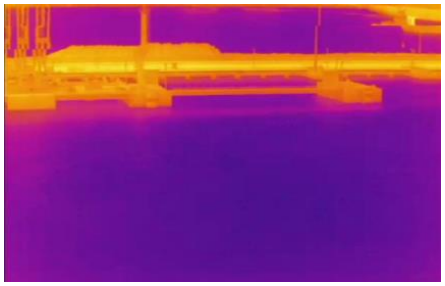
Thermal camera	Night vision
Create images from thermal energy (heat radiation)	Create images by amplifying visible light, e.g. moonlight
Can sense temperature difference as low as 0.05˚ Celsius	It can also detect invisible near infra-red light, thus an infra-red flashlight may be used to illuminate the scene
Operates in total darkness with unlimited range of visibility up to the horizon	Cannot operate in darkness; range of visibility is determined by having the right amount of visible or near infrared light available; too much light or too little can cause whiteout or blackout respectively
Creates high contrast images (day and night) making it easier to detect targets	Creates low contrast images at night limited by available visible light
Full field of view afforded by camera optics is available all of the time	Narrow beam width of infrared illuminator limits the field of view

Thermal imaging technology

What is thermal imaging?

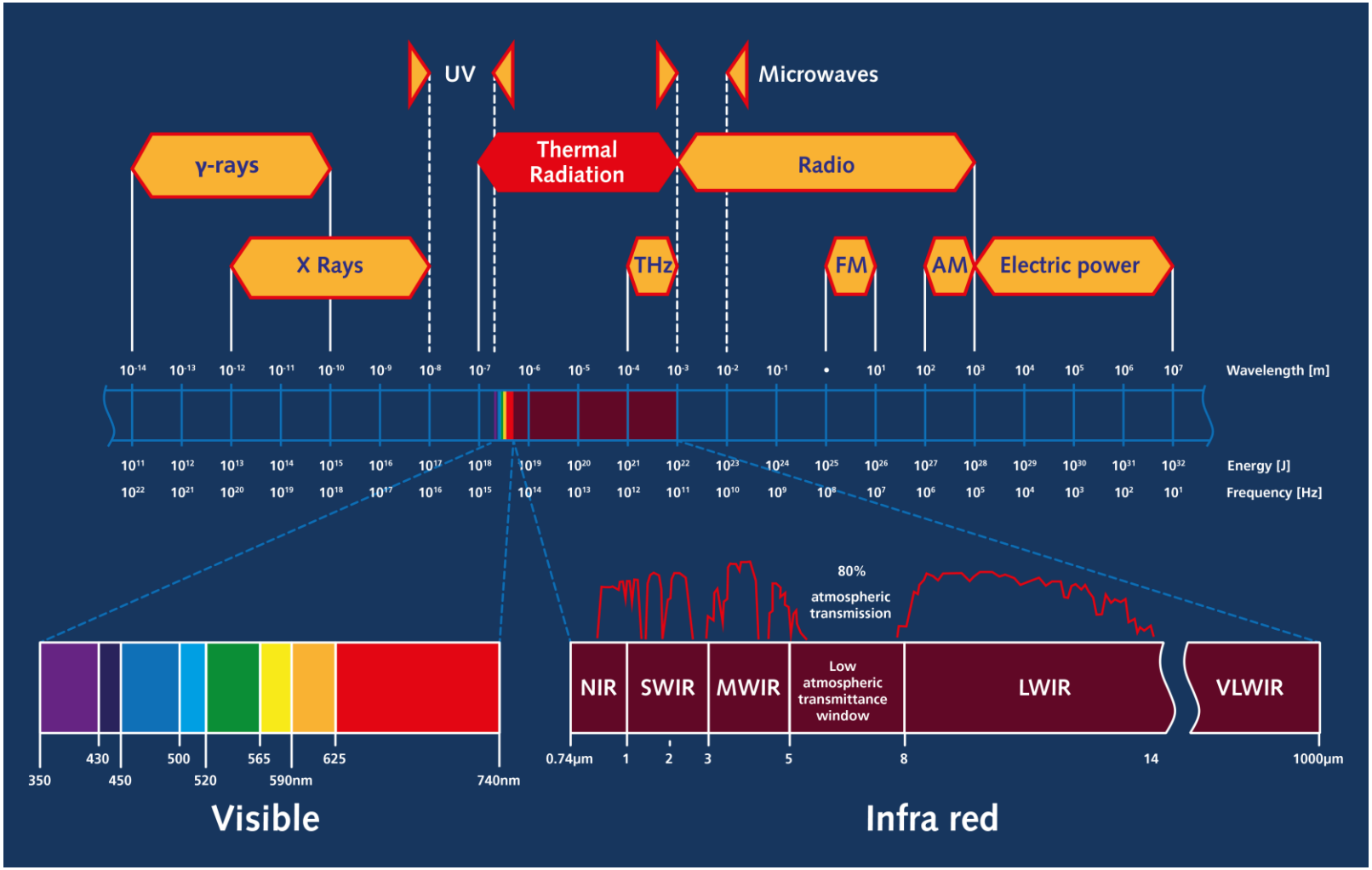
- Detects and produces image of thermal (heat) radiation in the infrared region
- Specifically the Long Wave Infrared (LWIR) region: 7.5 -14µm
- Can detect apparent temperature difference of up to 0.05˚C
- Can detect targets in warm water as well as in colder climate





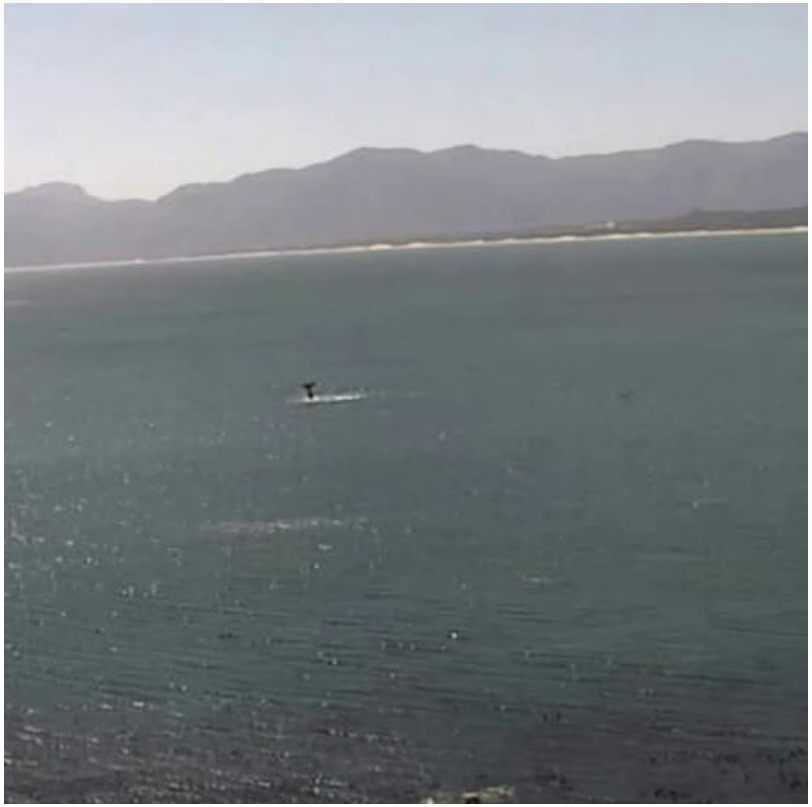
Seismic vessel at night 1.2km away

Electro-magnetic spectrum



Thermal image of marine mammals

- Southern right whales – Gansbaai, South Africa



HD visual image

Thermal image

Thermal image of marine mammals

- Southern right whales – Gansbaai, South Africa

HD visual image

Thermal image

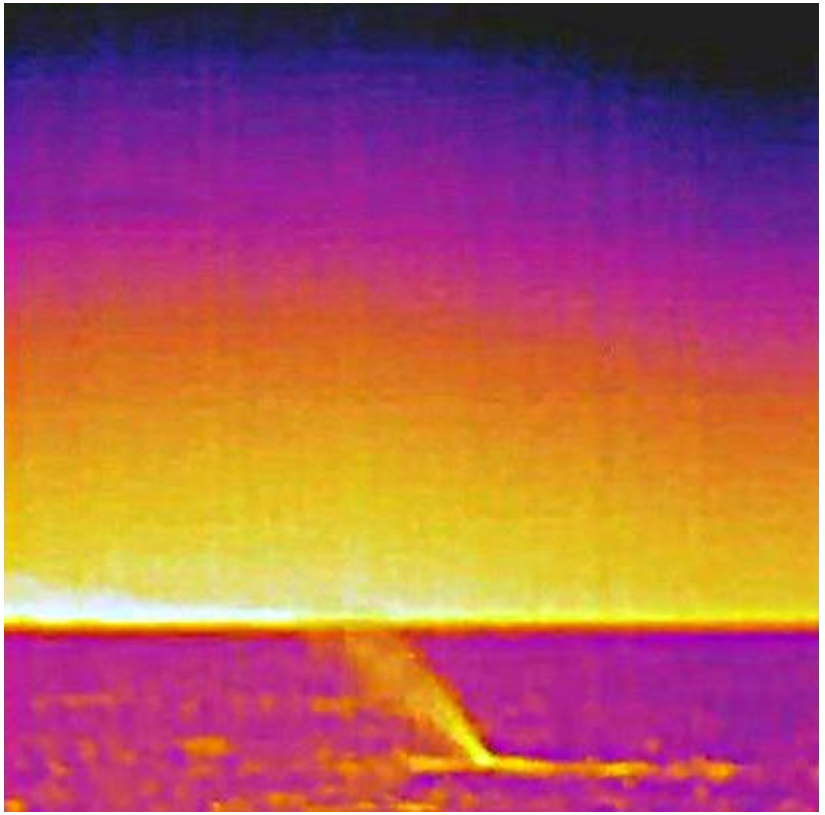
Thermal image of marine mammals

- Southern right whale breaching (video)

Thermal imaging – warmer water

- Sperm whale blow: 50m, Azores, Portugal, temperature up to 25˚C

HD visual image

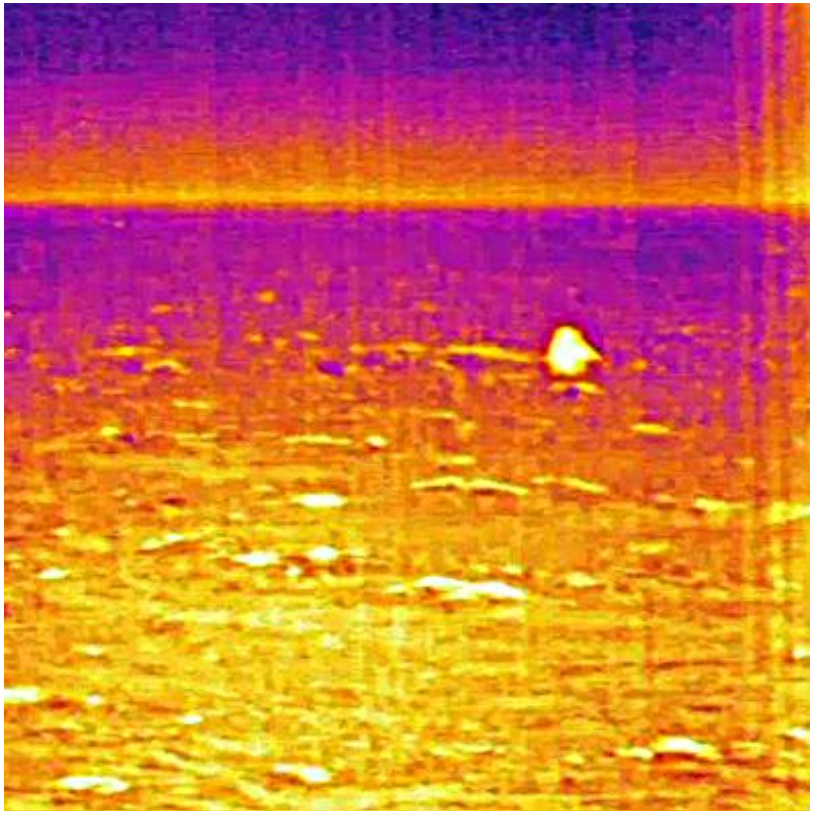


Thermal image

Thermal imaging – warmer water

- Sperm whale spy hopping: 70m, Azores, Portugal, temperature up to 25˚C

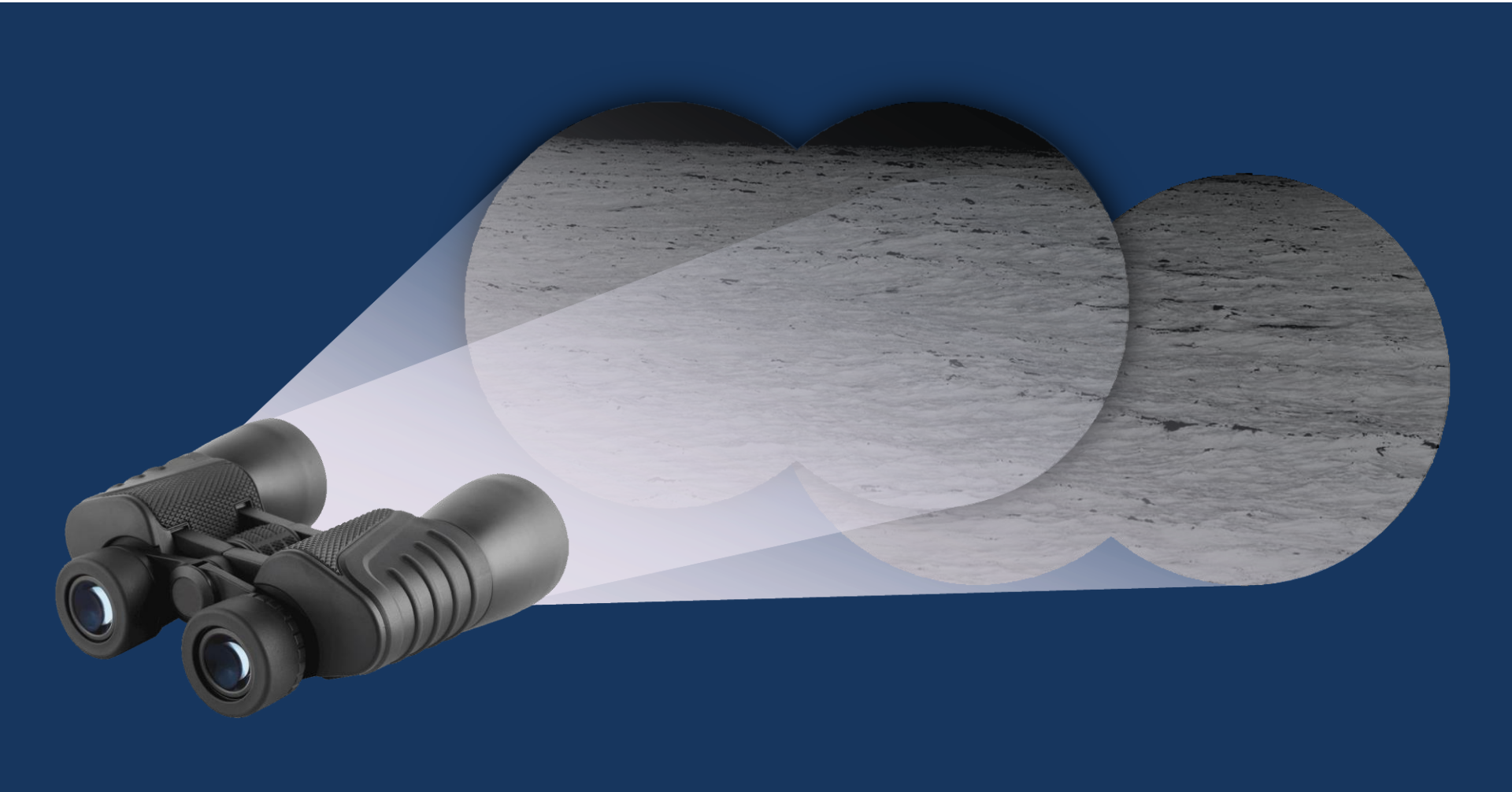
HD visual image



Thermal image

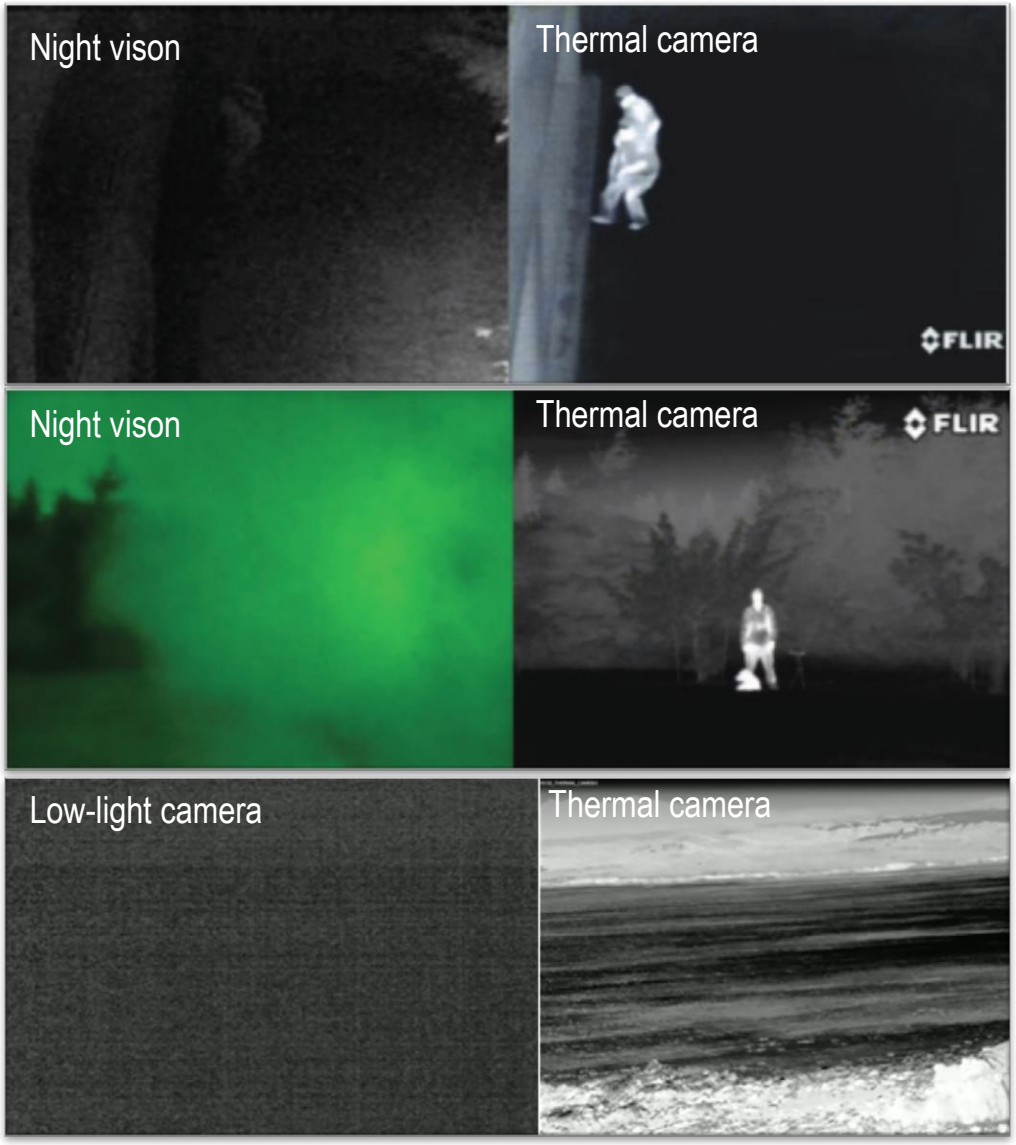
Thermal imaging vs night vision

- Animation showing limited field of view of night vision in darkness



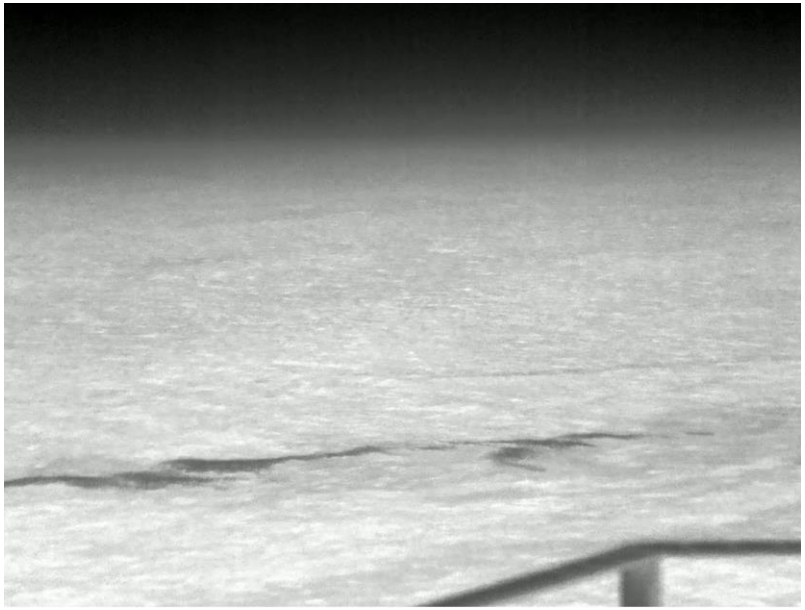
Thermal imaging vs night vision

Thermal imaging vs night vision



Heavy fog

- All devices suffer from degradation in haze especially heavy fog (< 300m visibility)
  - LWIR; Night vision; Short wave infrared (SWIR);LIDAR



Thermal image

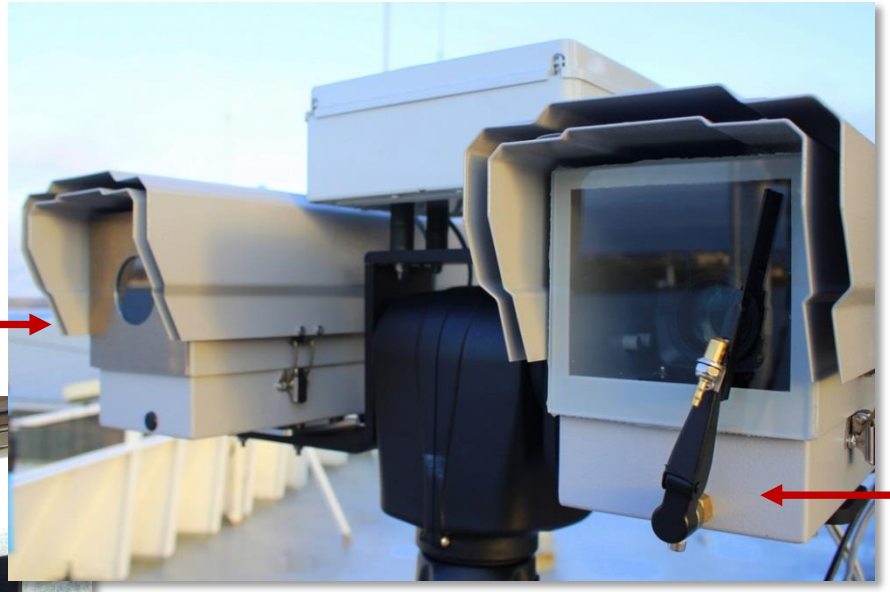
Visual image

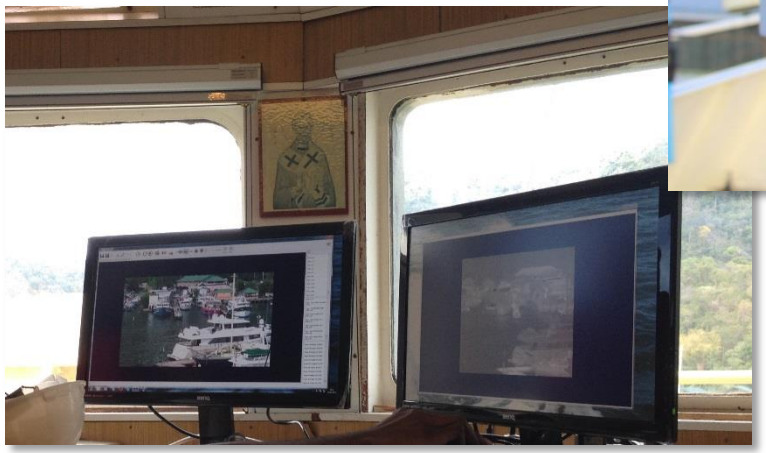
Gansbaai: light fog

Camera visual monitoring solution

Visual monitoring system

- Up to 360˚ coverage
- Allows remote monitoring (HSE benefits)

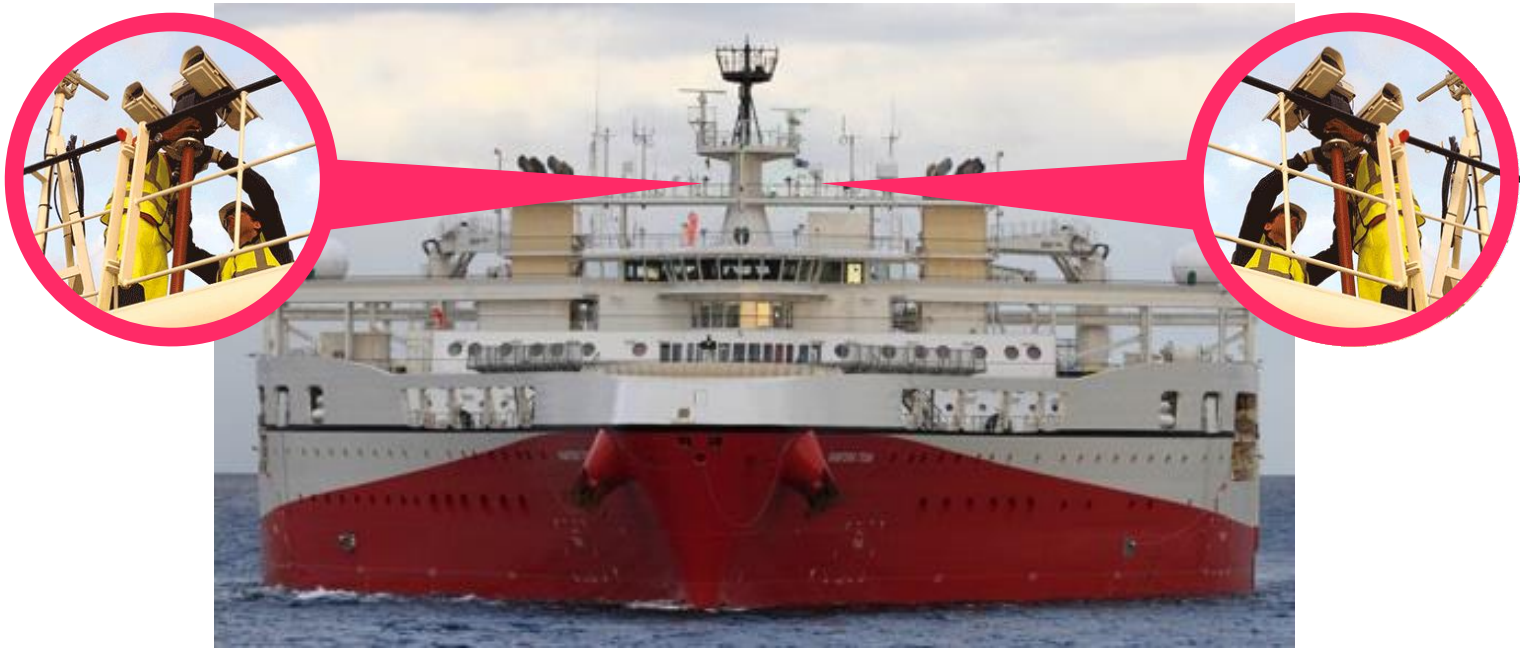




Dual camera monitoring units

Visual monitoring system

- HSE benefits and reduces the number of operators required for monitoring
  - Monitoring can be done from anywhere on the vessel
  - Multiple vessels can be linked and monitored from one location
  - Monitoring can be done over satellite

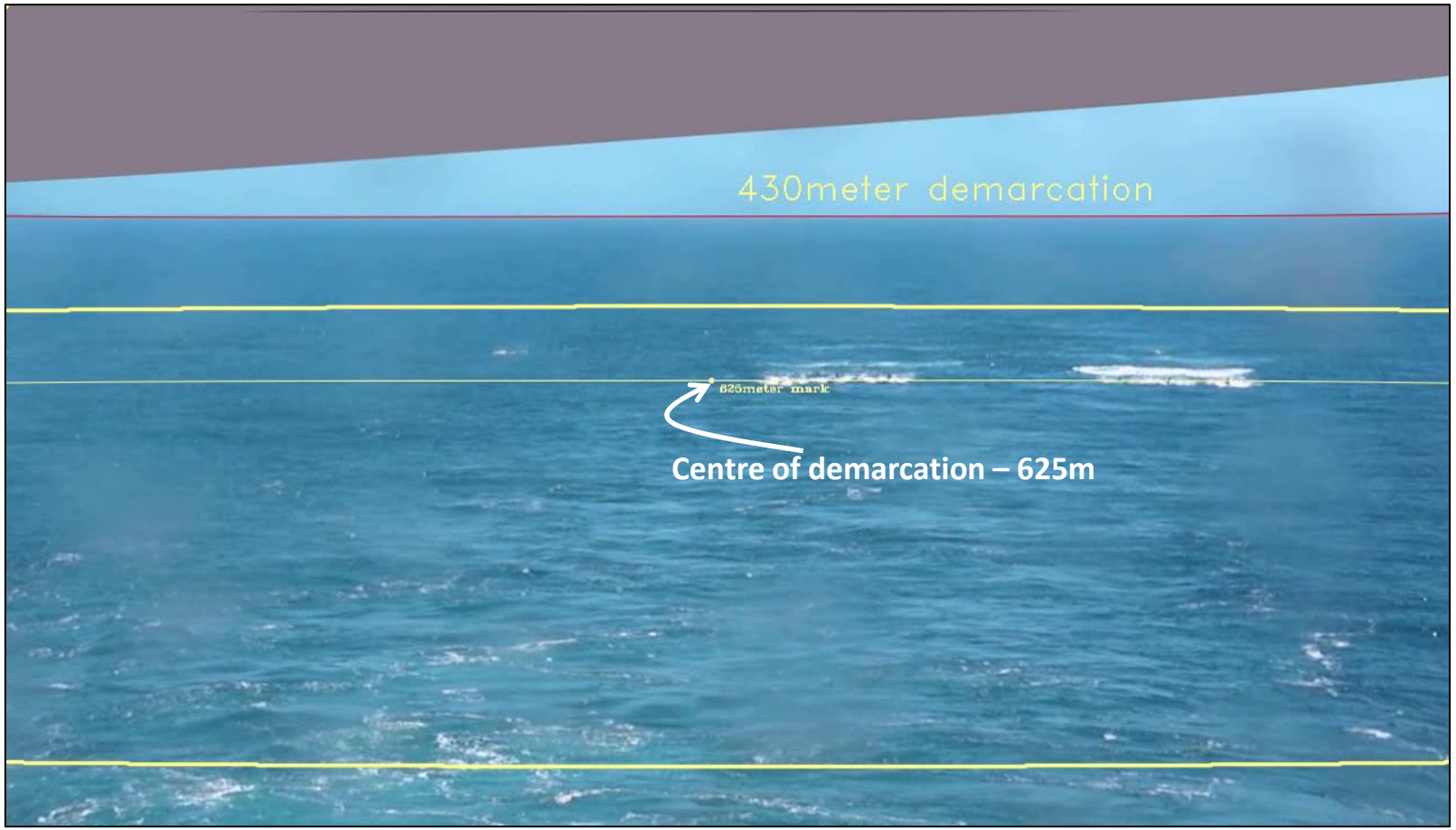


Visual monitoring system

- Camera monitoring system consisting of:
  - Dual camera unit
    - High definition cameras
    - Thermal cameras
    - Pan and Tilt unit
  - Seiche proprietary software
    - RADES (Real-time Automated Distance Estimation at Sea)
    - ARCS (Automated Recognition of Cetaceans at Sea): work in progress

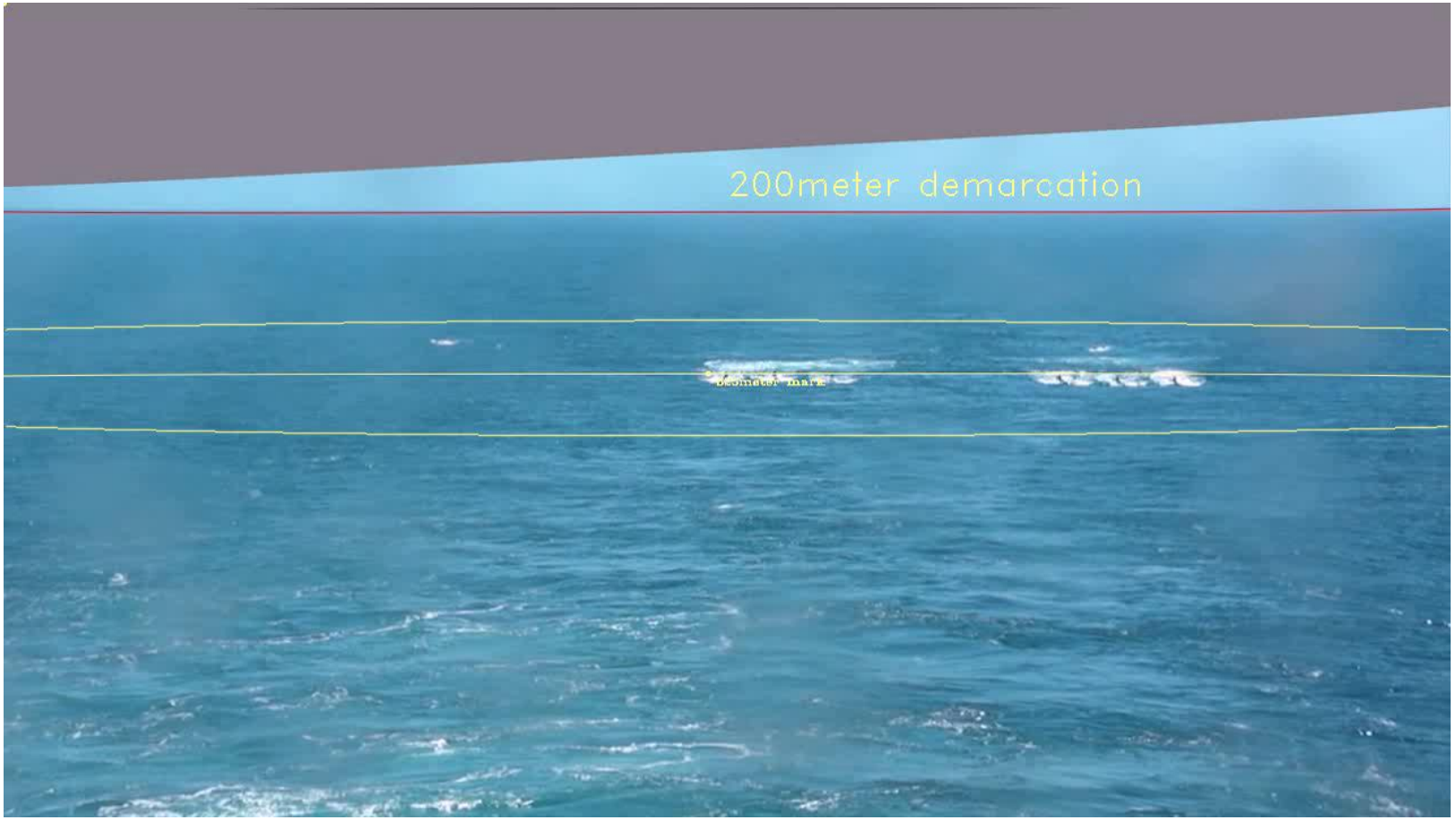
RADES – mitigation zone demarcation

- Anywhere below the yellow line is within the specified range of the camera



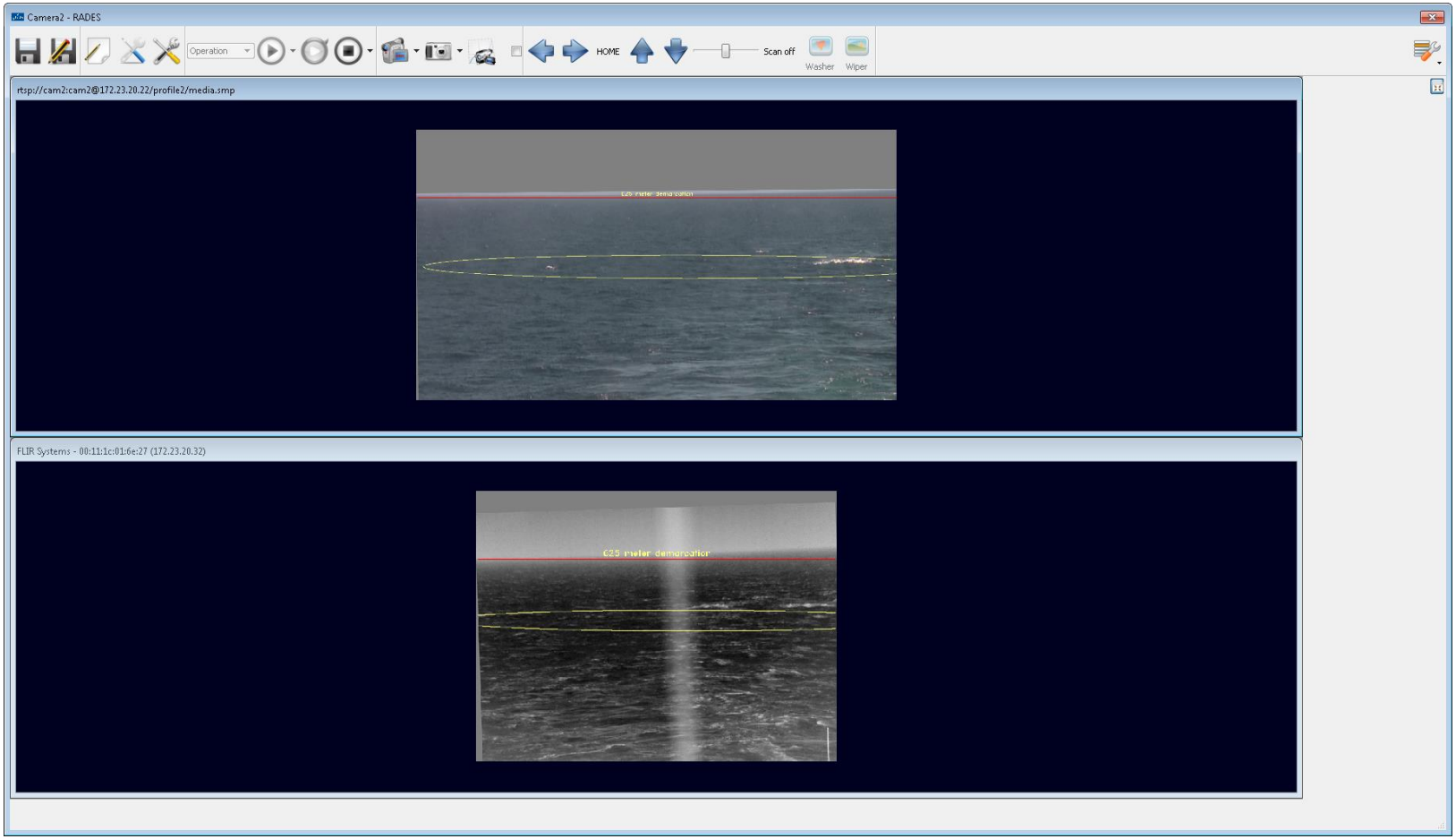
RADES – mitigation zone demarcation

- The yellow line demarks a specified radius



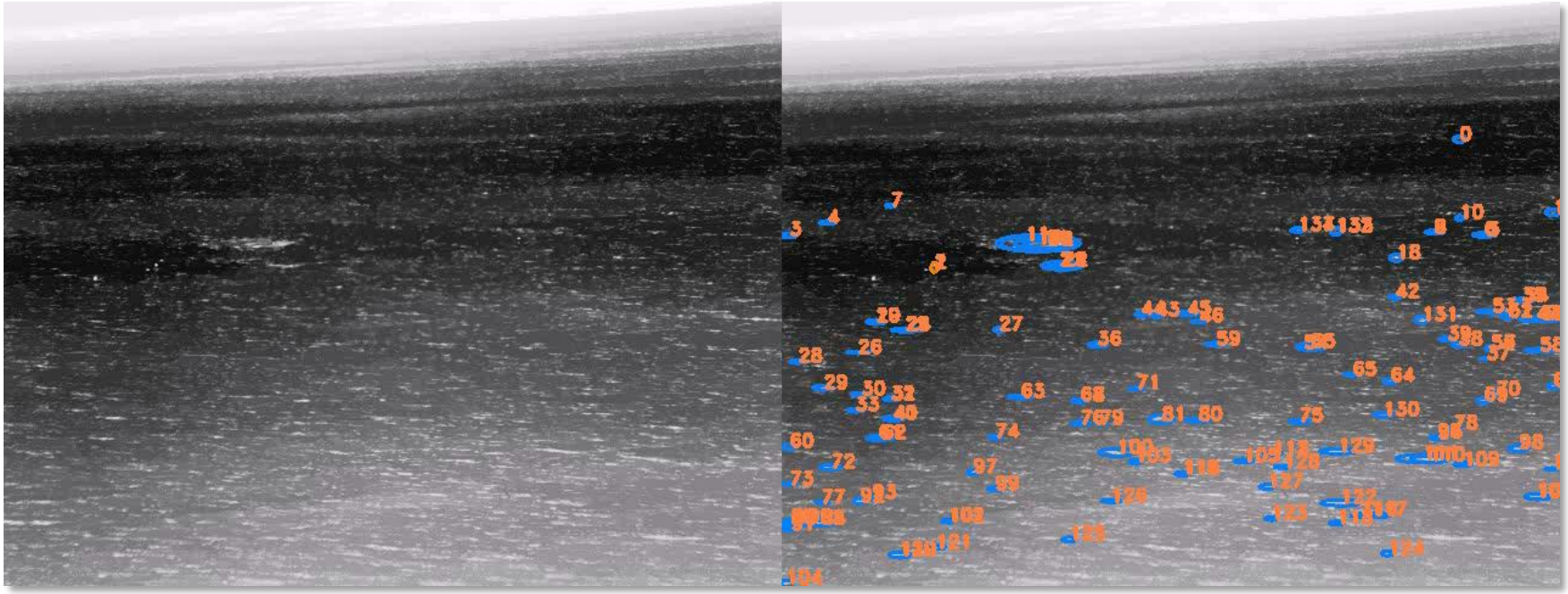
RADES – mitigation zone demarcation

- Snapshot on board vessel



ARCS – marine mammal detection

- Southern-right whale: Gansbaai

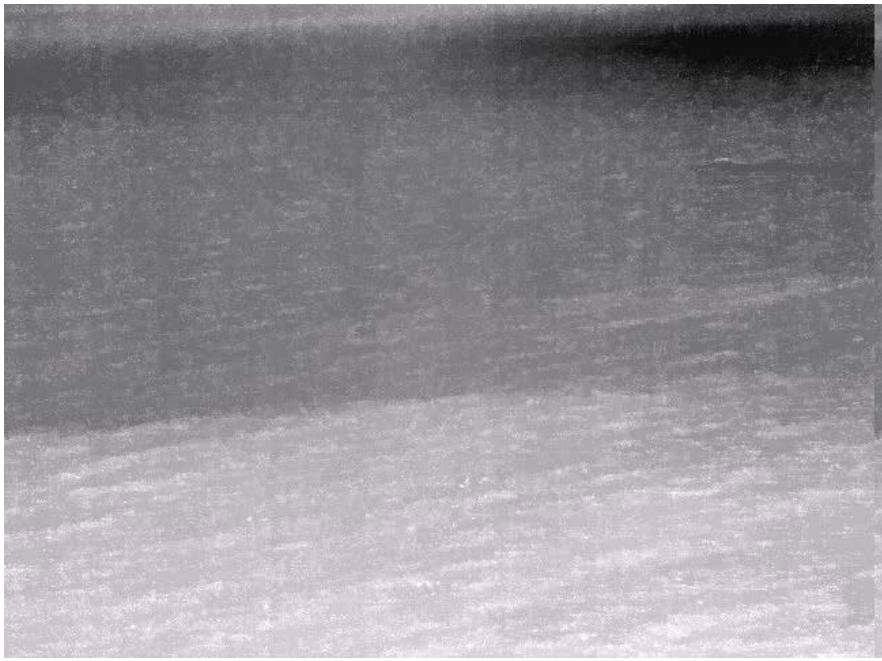


Detected blow

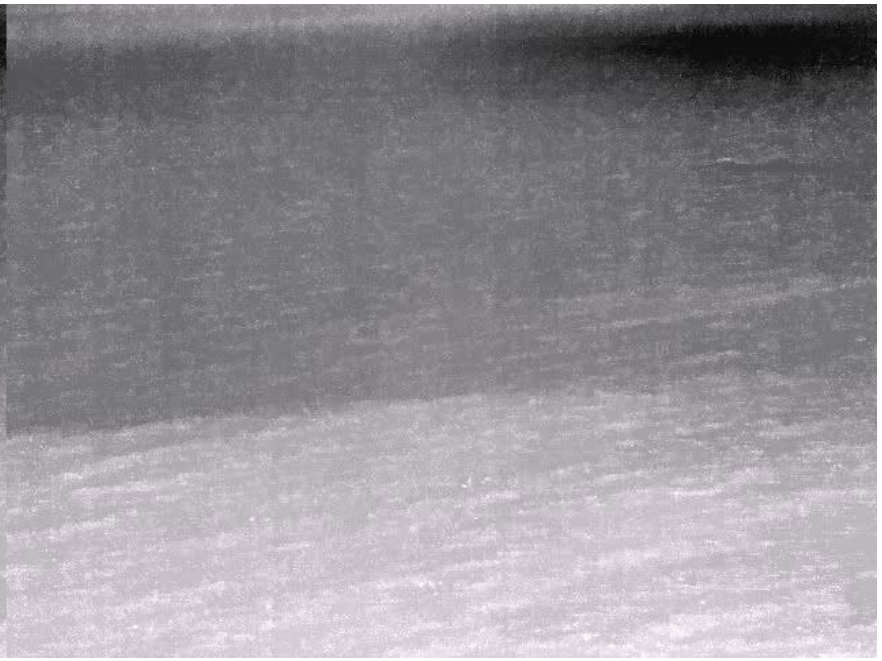
Potential blow tracking

ARCS – marine mammal detection

- Southern-right whale: Gansbaai



Detected blow



Potential blow tracking

Other applications

Birds and bats monitoring

- Gansbaai, South Africa

HD image

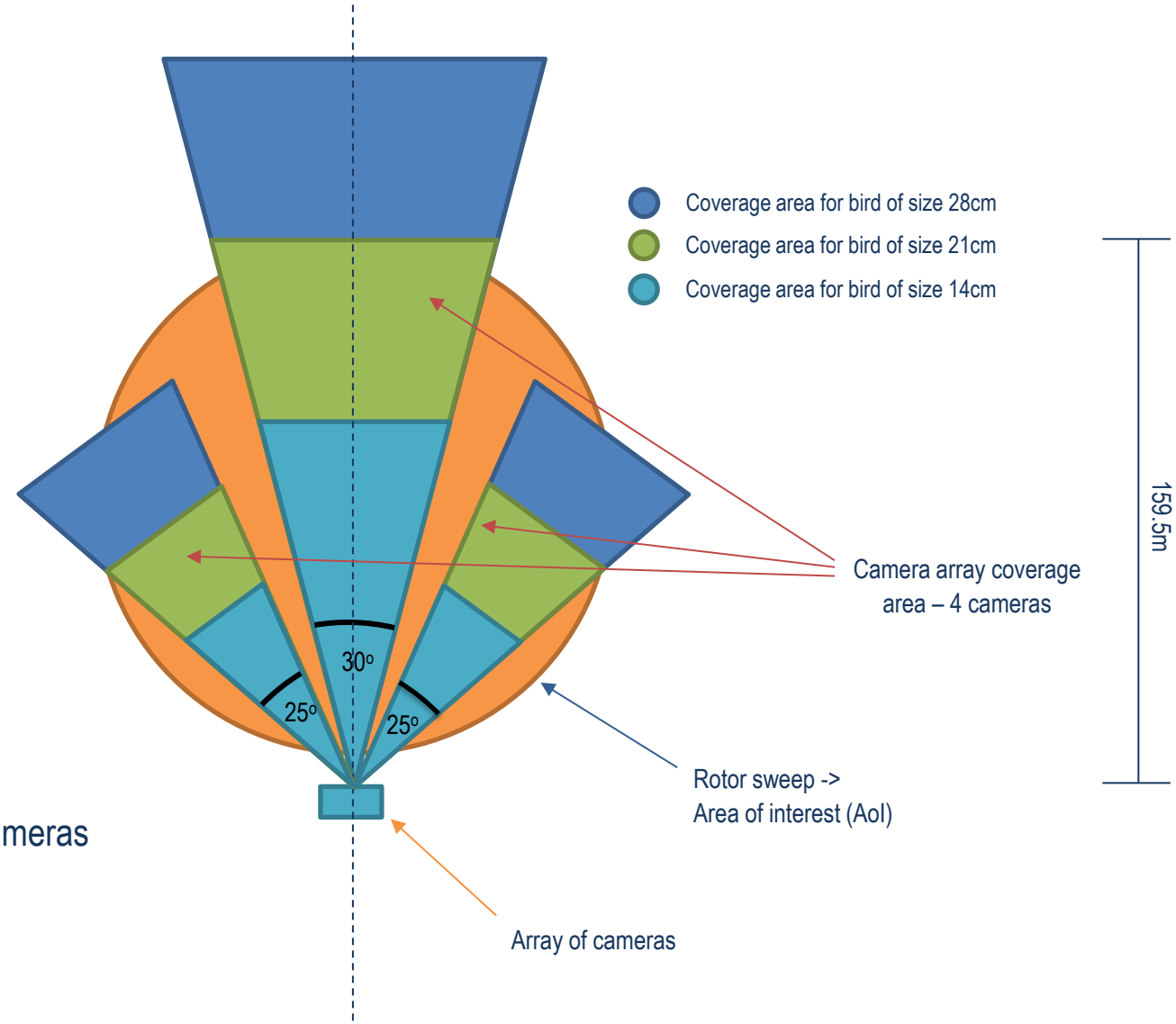
IR image

Birds and bats monitoring

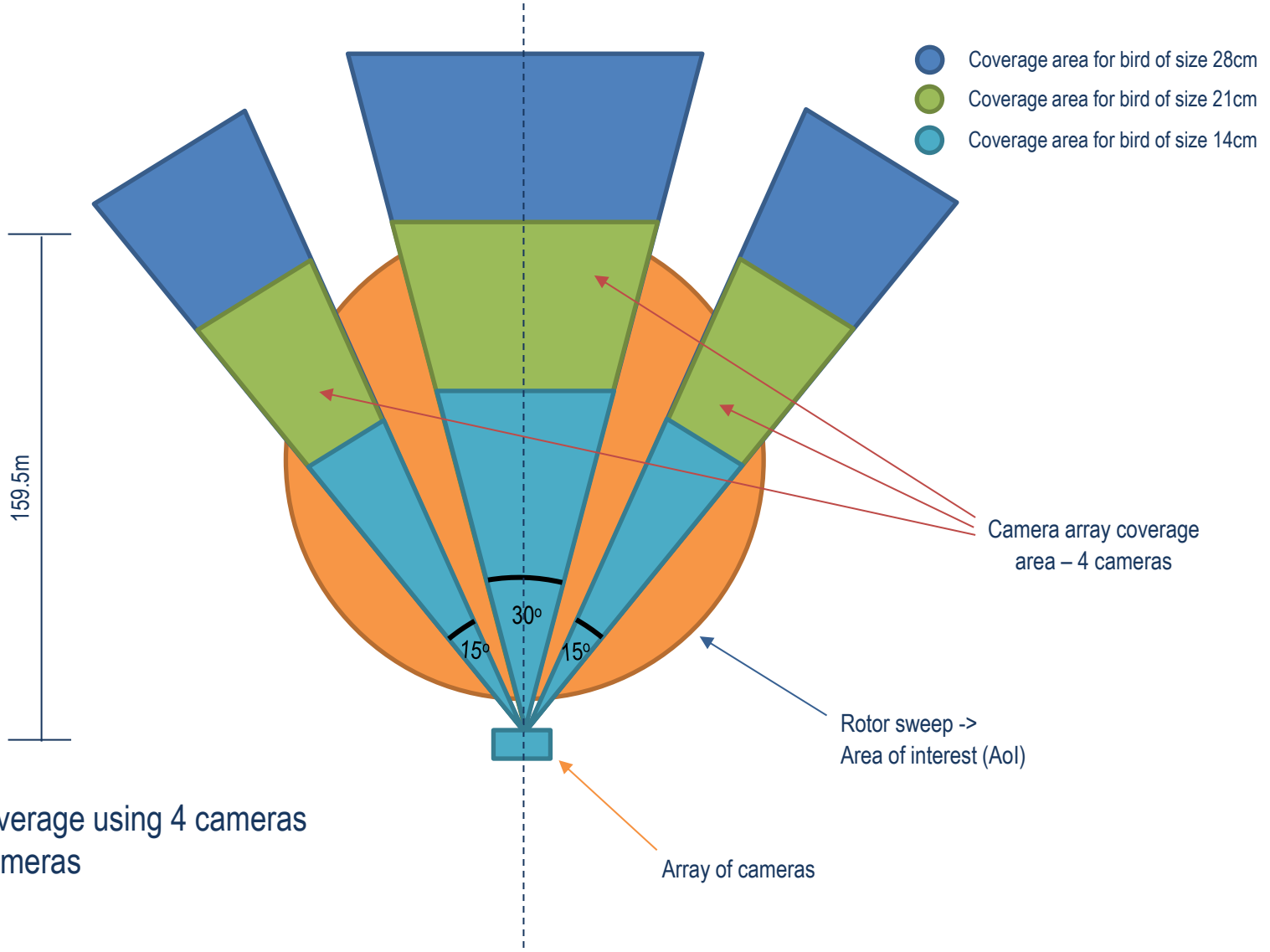
- Cormorants – Gansbaai, South Africa (Video)

Wind turbine generator

Camera coverage using 4 cameras
- 2 x 15º cameras
- 2 x 25º cameras



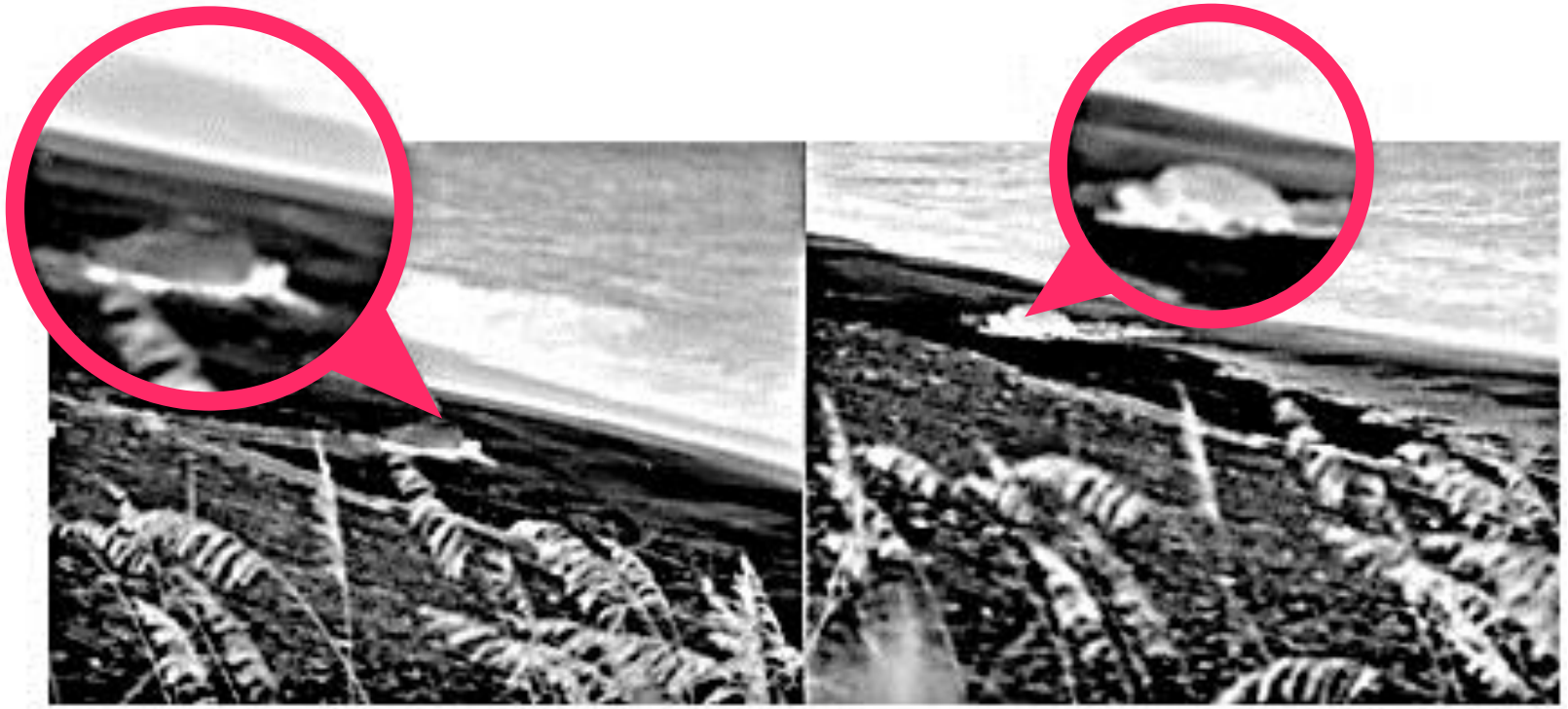
Wind turbine generator



Camera coverage using 4 cameras
- 4 x 15° cameras

Turtle nesting monitoring

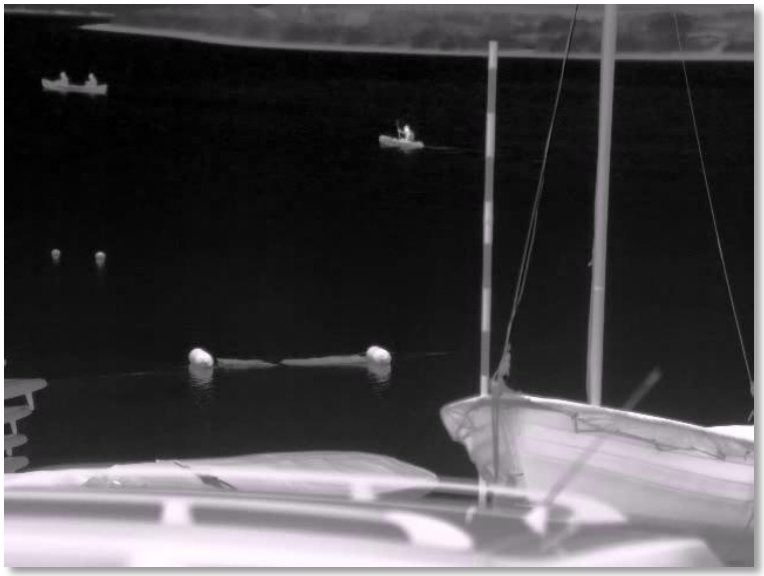
- Trial undertaken on a Florida beach



Sea surface debris and obstacles

- Hazards such as small fishing boats, fish attracting devices (FAD) and debris on water surface
- FAD and Kayaker easily detected with high contrast

Fish attracting devices (Source PGS)



Trials: detection of simulate fish attracting device in thermal camera

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