



Space-based surveillance tools for fisheries control

Overview and JRC work

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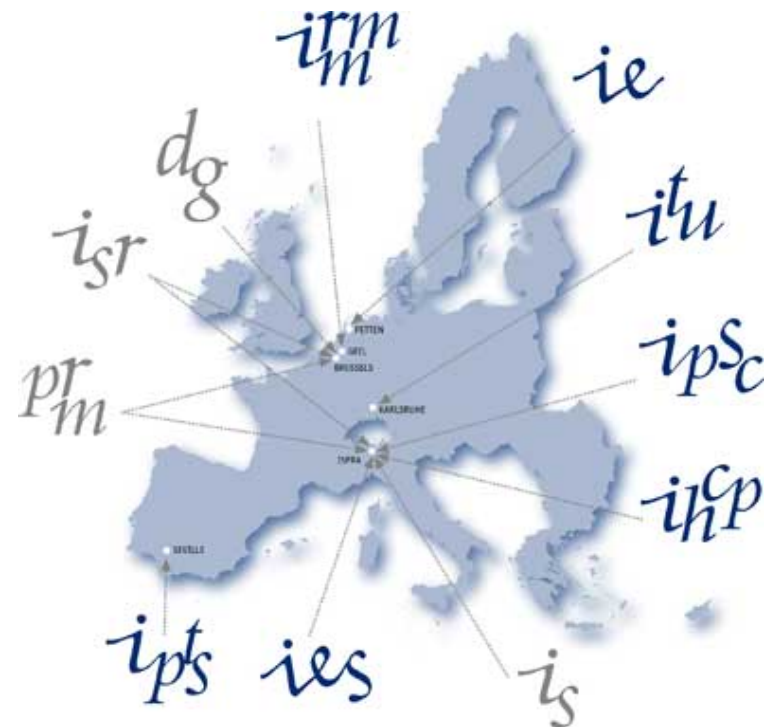
Contents

- **Possibilities with space-based surveillance**
 - Finding ships
 - (a) Ship reporting data and (b) Imaging
 - Finding fish
 - Habitat mapping
- **Status of the technologies**
- **Limitations of space-based surveillance**
- **Conclusions**



Joint Research Centre (JRC)

- Internal science service of the European Commission
- Scientific and technical support for European Union policies
 - Conception, development, implementation, monitoring
- Reference centre of science and technology for the EU
- Serves the common interest of the Member States
- 7 Institutes, 5 sites



Space-based surveillance possibilities

(a) AIS reception by satellite:
Get AIS data far from the coast



Coastal AIS (marinetraffic.com)

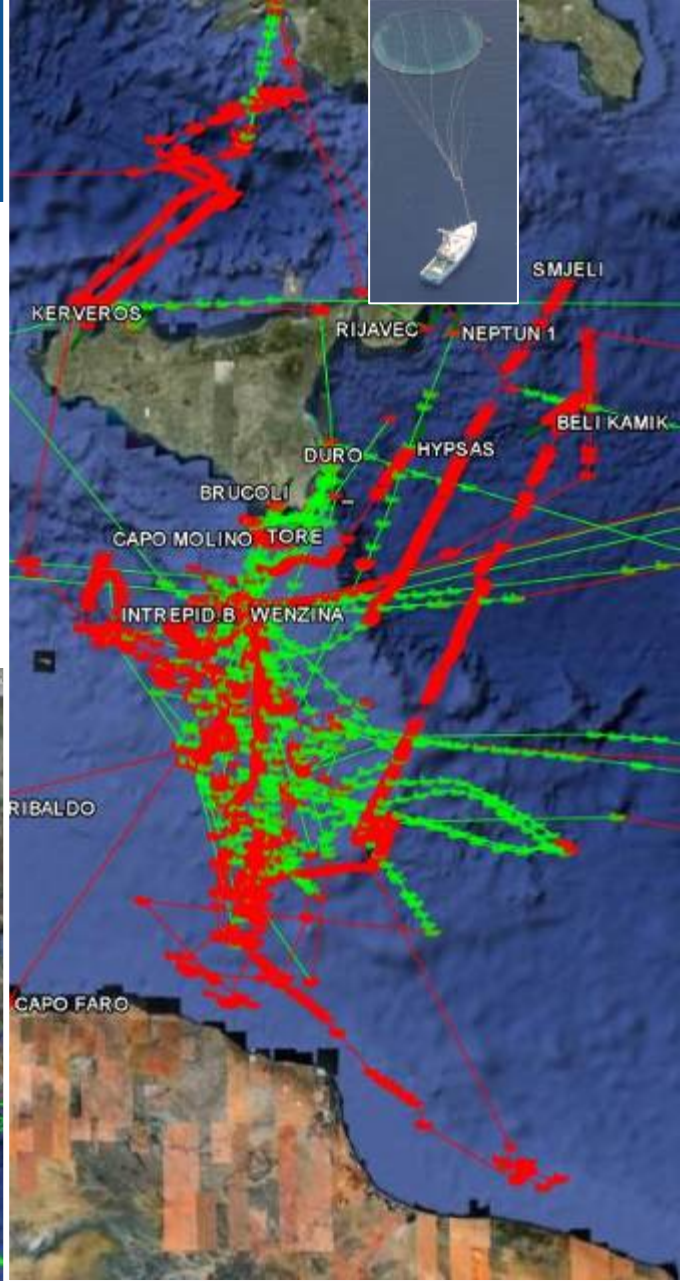
- **Ship reporting data: VMS, AIS, LRIT, ...**
 - AIS: short messages with ship info on VHF
- **AIS on merchant ships under IMO regulations (global), possibly extended with national ones**
 - Reefers, tows, some larger fishing vessels, ...
 - EU regulation 2011/15/EU: fishing vessels > 15 m (2014+)
- **Coastal AIS receivers give local picture**
 - to 40 nm, sometimes to several 100 nm
- **Sharing networks → wider coastal picture**
 - Government, commercial
- **Satellites give global picture**



AIS for monitoring

Monitoring farming vessels

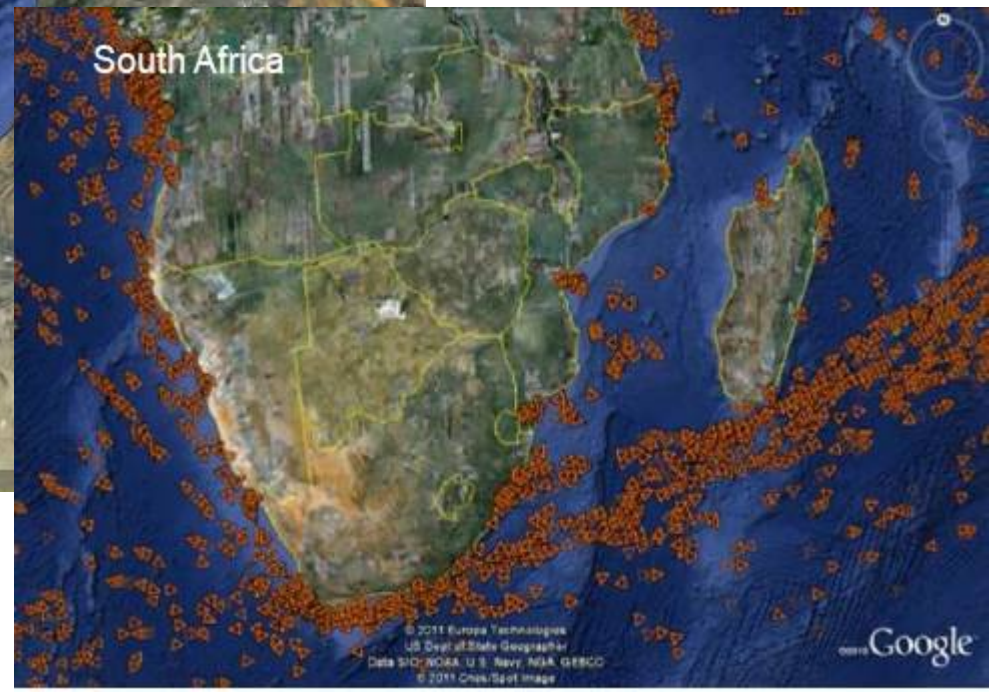
Done in 2008 with coastal AIS



Monitoring reefers



LuxSpace VesselSat-1 (Oct 2011 -)



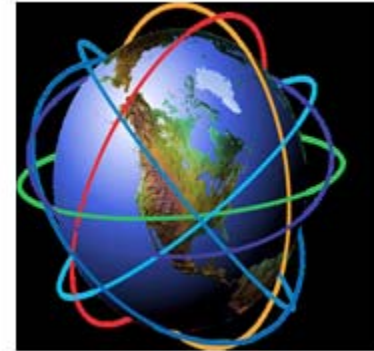
Three consecutive overpasses

Courtesy **LUXSPACE**
An OHB Company

Satellite AIS systems

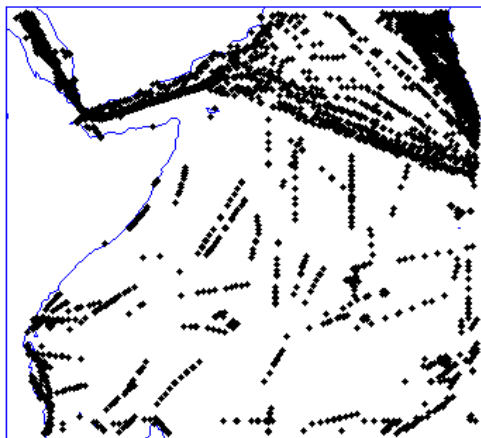


- **OrbComm**
 - First to implement in space
 - Plans for large constellation
- **LuxSpace**
 - Fly own missions and build for OrbComm
- **exactEarth**
 - Including SpaceQuest
- **Norway-FFI**
 - AISSat-1, and NORAIS on ISS
- **ESA-EMSA**
 - Discussed
- **Experimental systems**
 - From universities, ...



Example: LuxSpace Sat-AIS

LuxSpace 1 day (20 Dec 2011)



Lon (21507 pts)

1 day

1 week

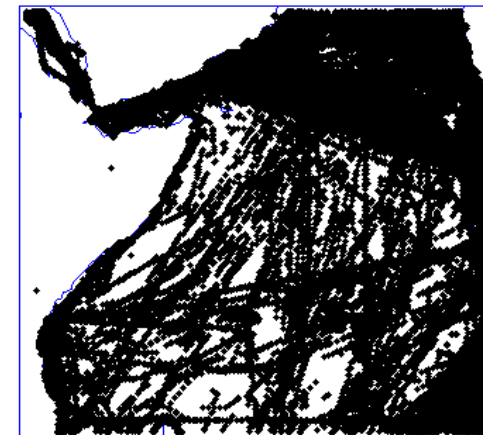
LuxSpace 1 week (20-26 Dec 2011)



Lon (178485 pts)

1 month

LuxSpace 1 month (Dec 2011)



Lon (641340 pts)

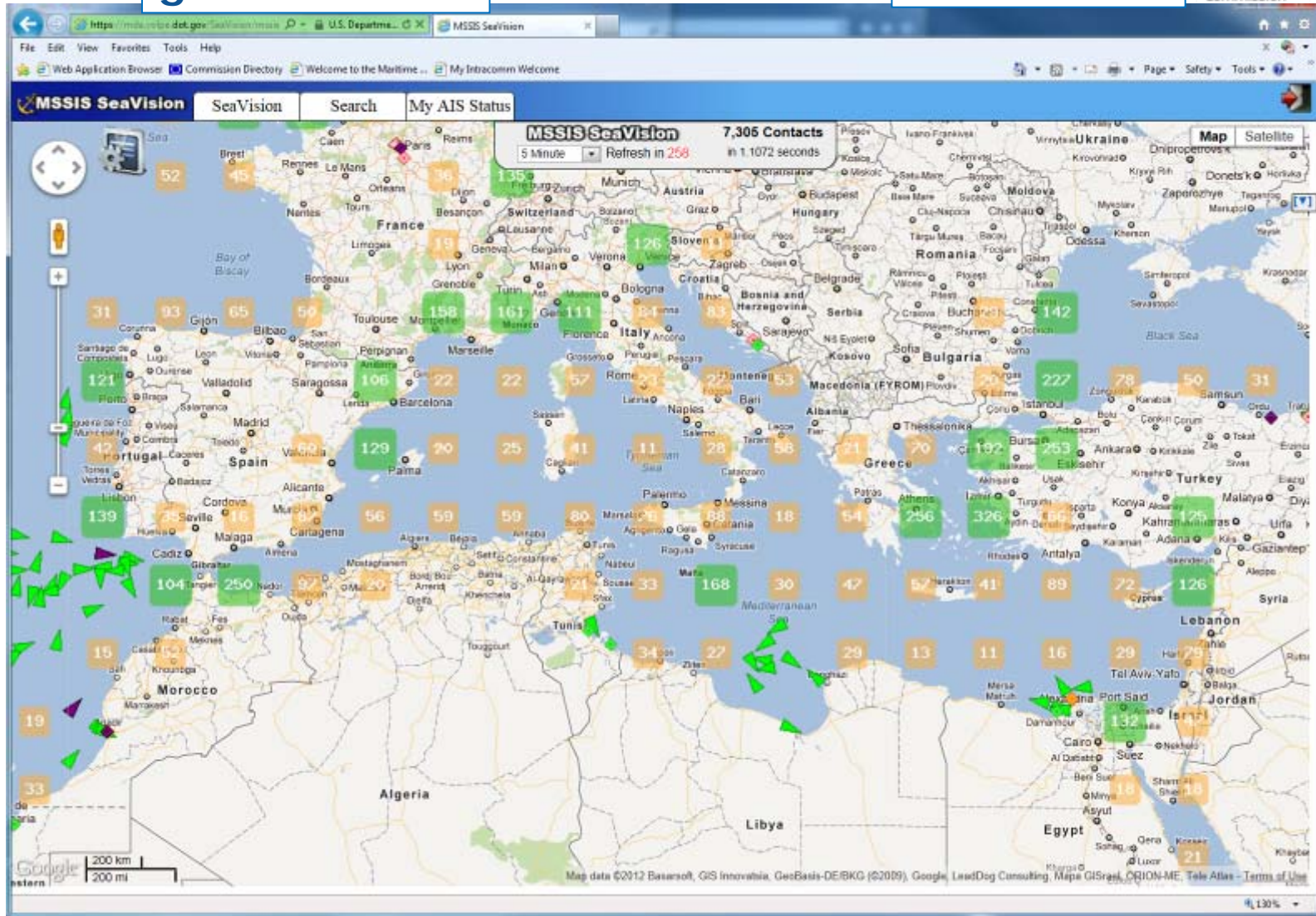
Collected in "PMAR" project on maritime surveillance for counter-piracy

AIS network: MSSIS / SeaVision

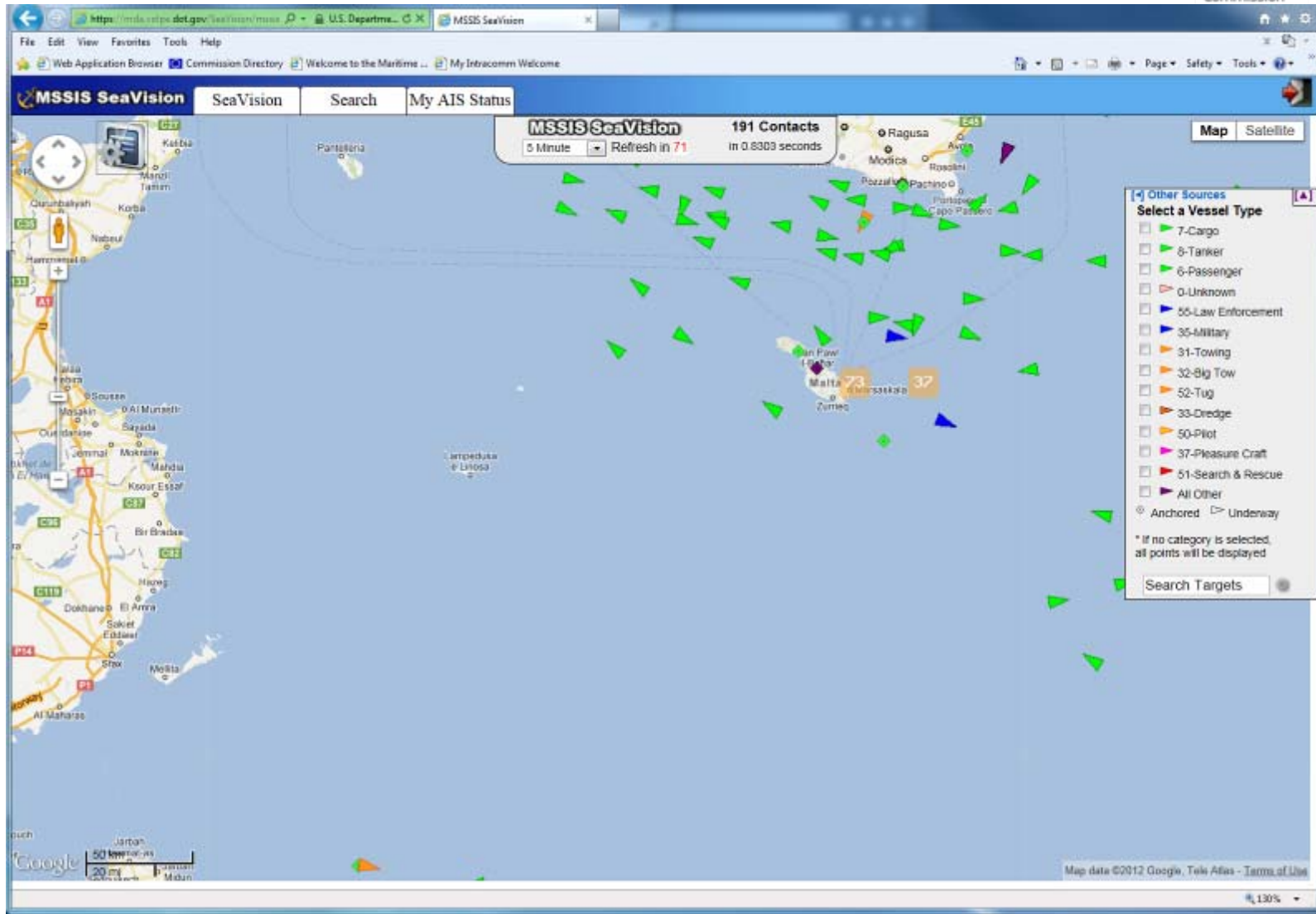


governmental

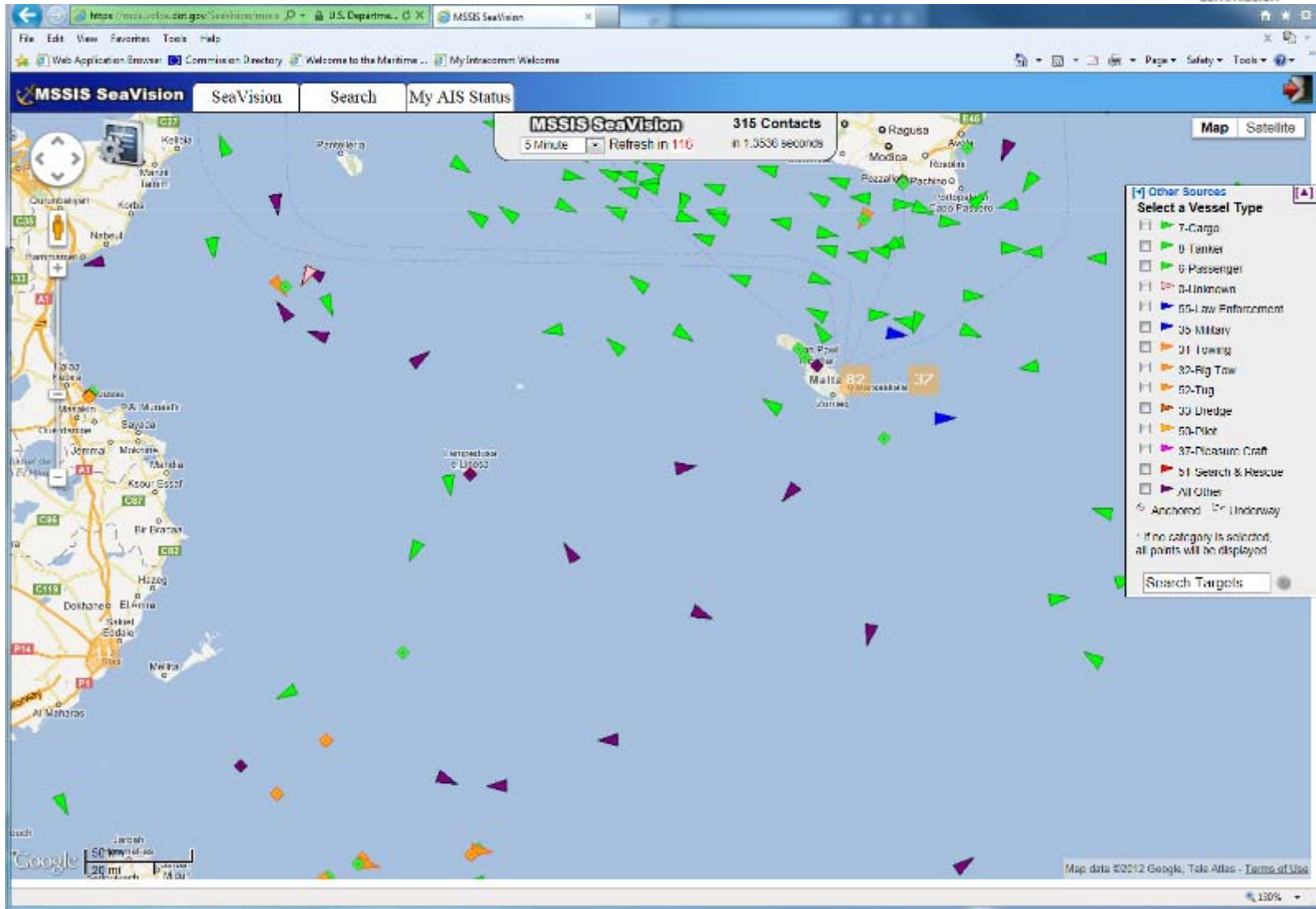
web viewer



MSSIS SeaVision – <1 hr



MSSIS SeaVision – <12 hr Incl. Sat-AIS (exactEarth)



MSSIS SeaVision – <12 hr



MSSIS SeaVision 316 Contacts
5 Minute Refresh in 164 In 1.0036 seconds

Apostolos A
MMSI: 240654000
IMO: 9190305
Ship Type: Tanker
Status: 0-1 Underway (Engine)
Speed/Heading: 12.7 knots / 209 °
Length*Beam*Draft: 152m x 32m x 8.2m
Latitude/Longitude: 35.1785 / 12.3358
Destination: La Sidiira
ETA: unavailable
Received: April 23rd, 2012 04:09 UTC
6h, 12min, 11s ago
Source: EXACTEARTH_AF
[Google History Trail](#)

Agostino Padre
MMSI: 249000102
IMO: 0
Ship Type: Fishing
Status: 7-Engaged in Fishing
Destination: ETA: unavailable
Received: April 23rd, 2012 08:06 UTC
1h, 24min, 59s ago
Source: MSSIS
[Toggle History Trail](#)

Select a Vessel Type

- 7-Cargo
- 8-Tanker
- 6-Passenger
- 0 Unknown
- 00 Law Enforcement
- 35-Military
- 31-Towing
- 32-Big Tow
- 52-Tug
- 33-Dredge
- 50-Pilot
- 37-Pleasure Craft
- 51 Search & Rescue
- All Other
- Anchored
- Underway

* If no category is selected, all points will be displayed.

Search Targets

Space-based surveillance possibilities



(b) Satellite imaging

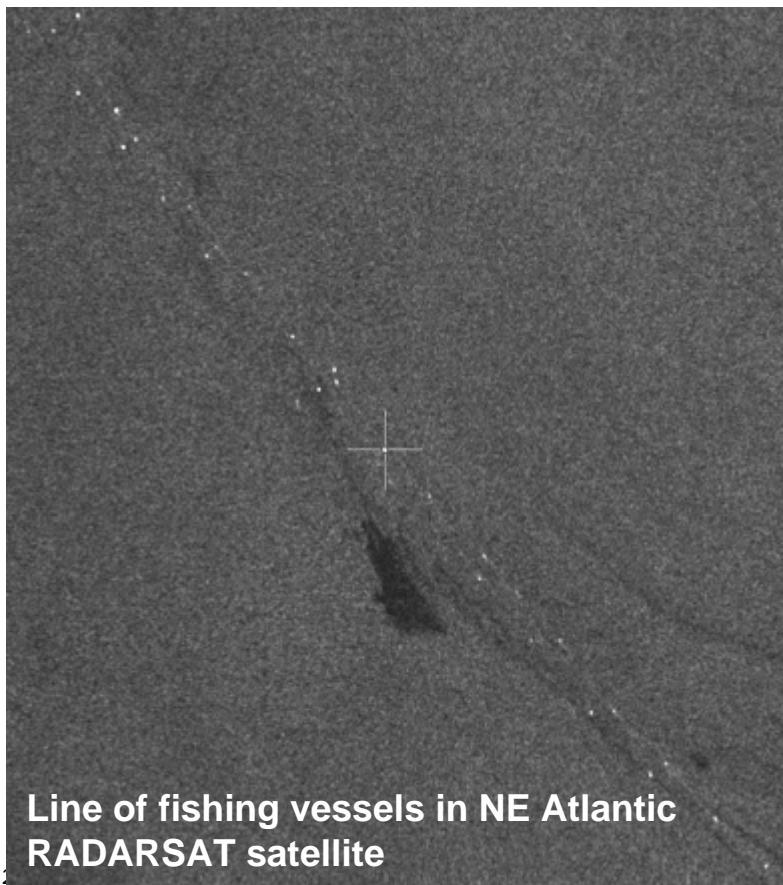
- Find ships anywhere
- Also if not reporting (on VMS, AIS, ...)
- Also with clouds, at night, by using radar
- Combine with simultaneous reporting data to pinpoint non-reporting ships

Satellite images



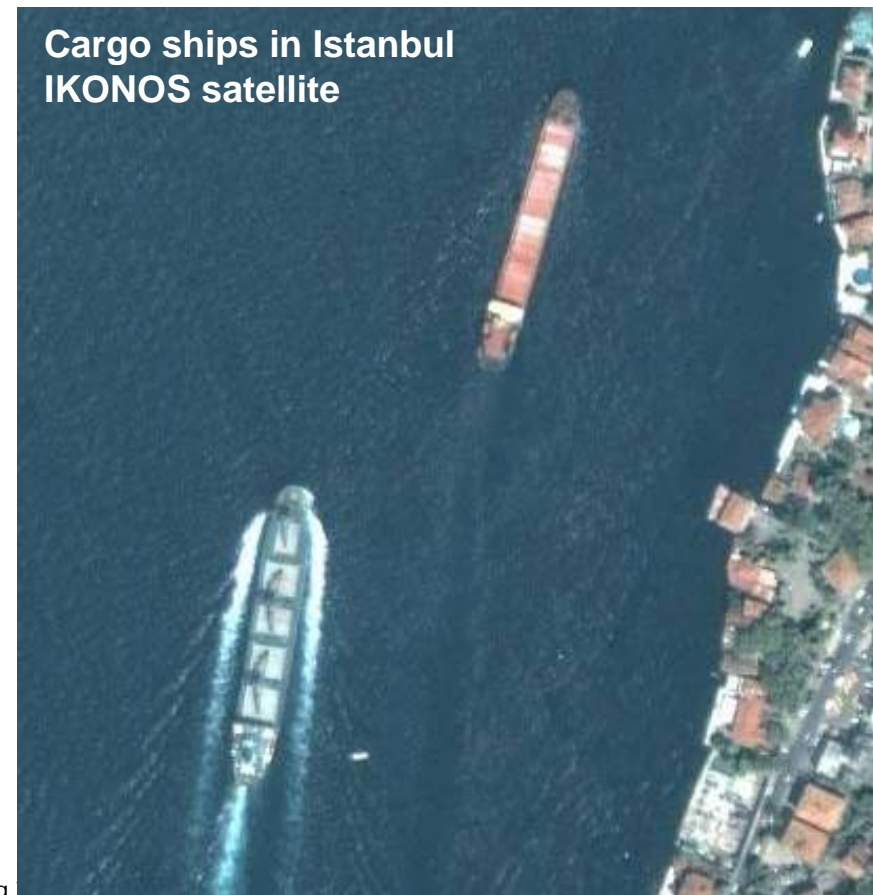
Radar

- Independent clouds, night
- Better for wide areas
- Use for detection

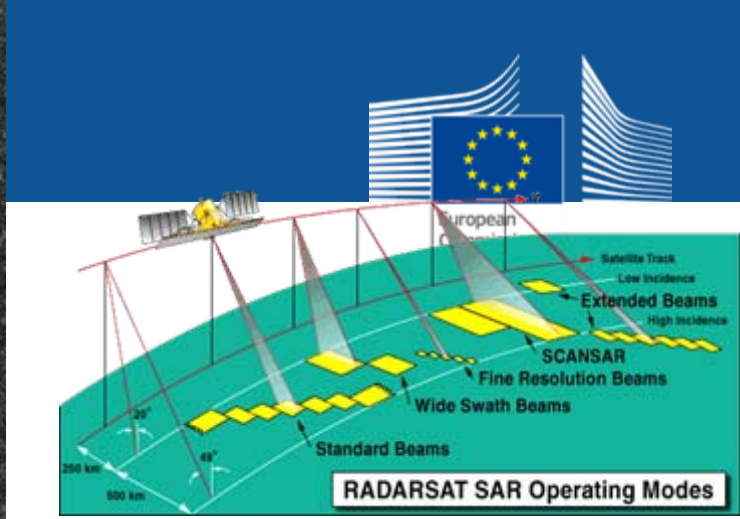
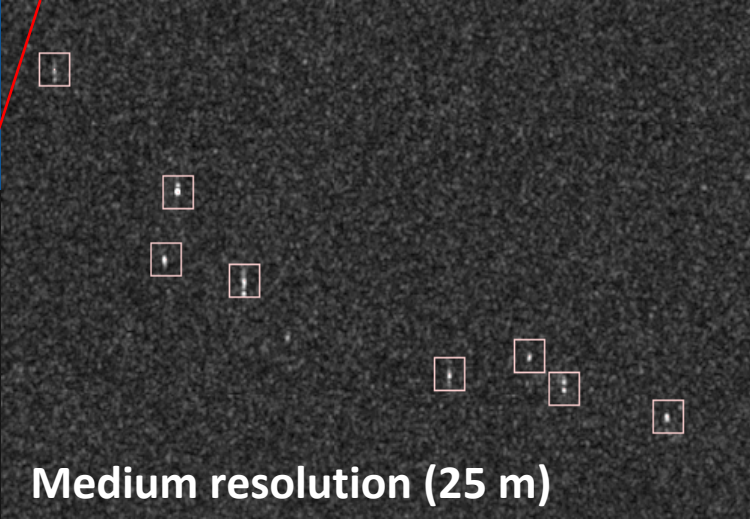
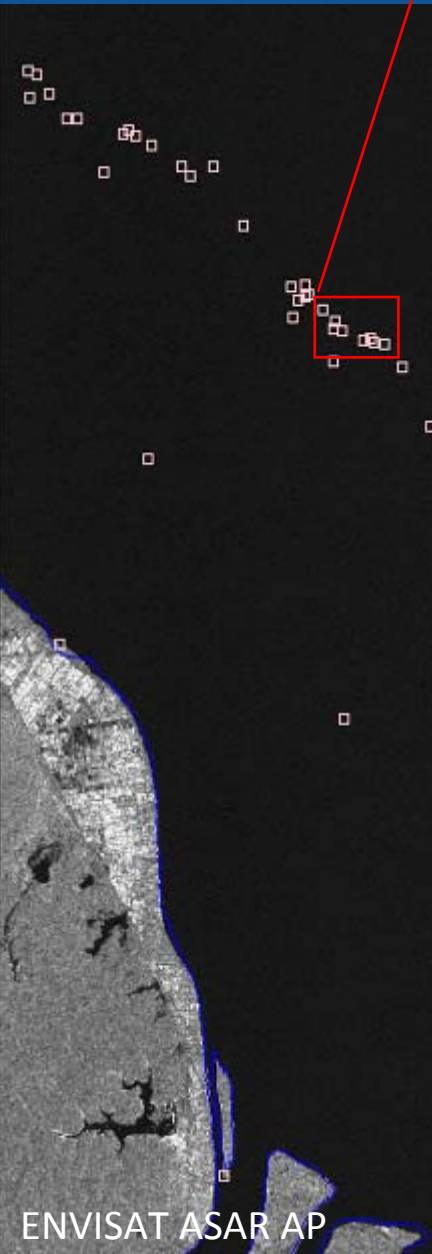


Optical

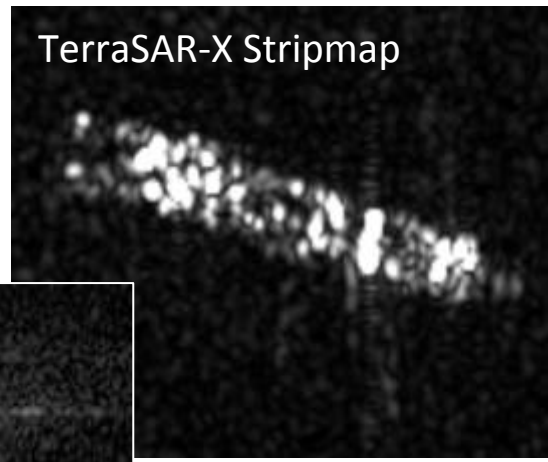
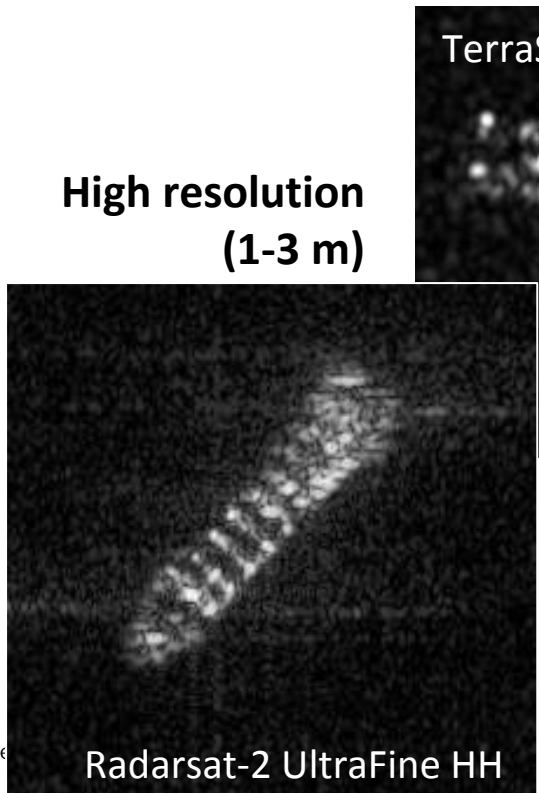
- Only daytime, clear skies
- Better for details
- Use for recognition



Satellite SAR



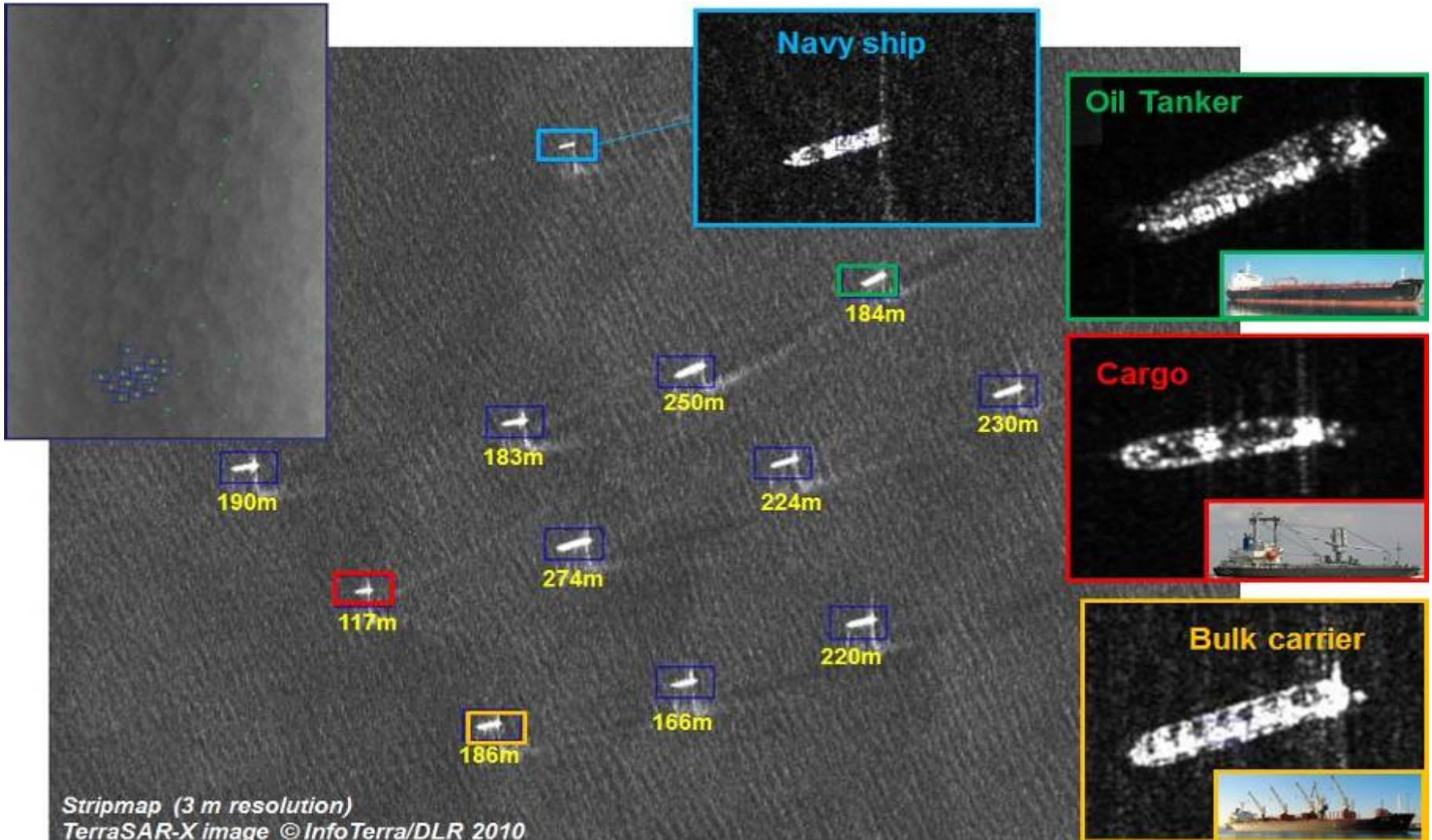
Synthetic Aperture Radar images



Recent SAR satellites have <3 m resolution Radarsat-2, TerraSAR-X, CosmoSkymed



Example: Gulf of Aden, 5 Dec 2010



Stripmap (3 m resolution)
TerraSAR-X image © InfoTerra/DLR 2010

Date

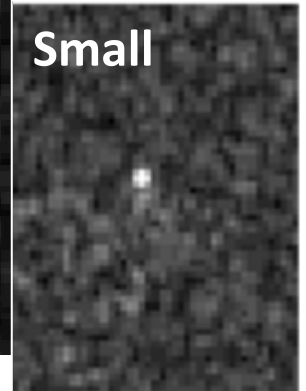
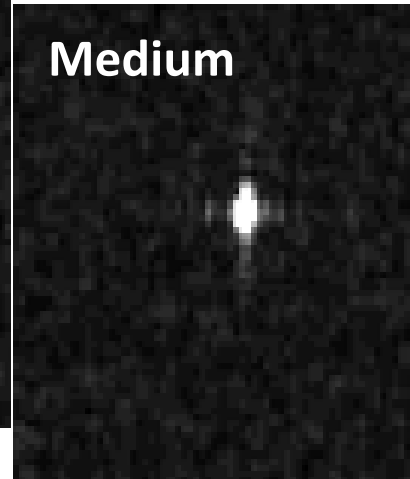
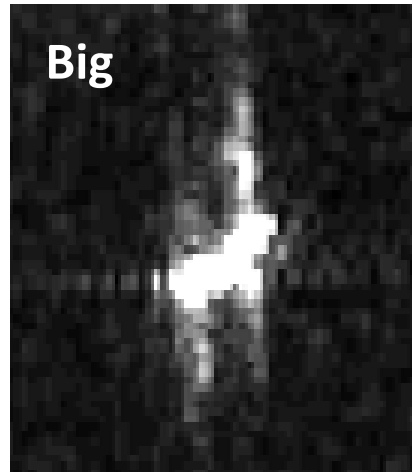
Footer

Detecting ships and cages

But medium resolution (15-25 m) has wider swath and may be good enough

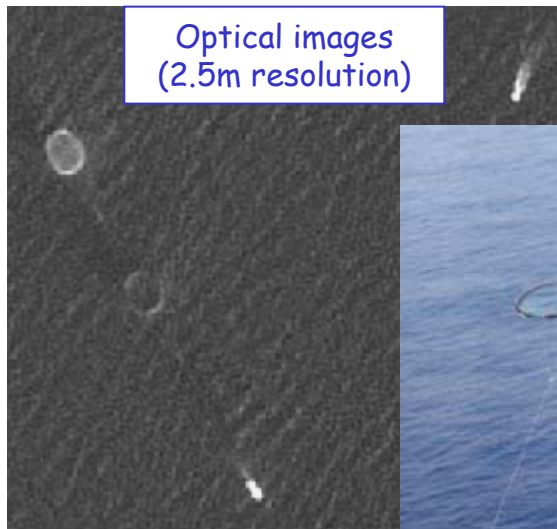
ESA: Sentinel-1 (2014)

Ships



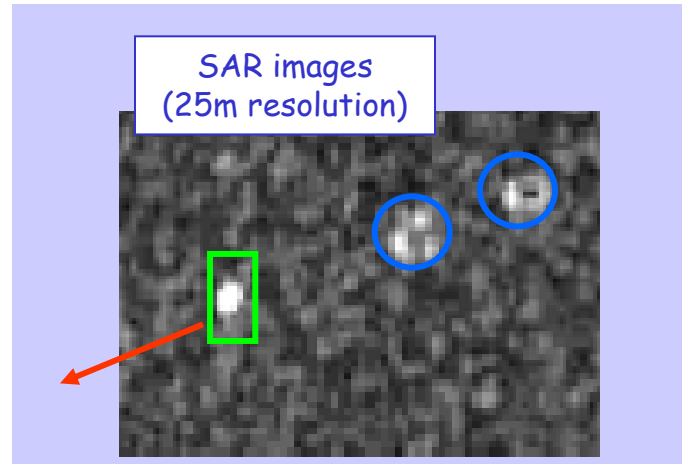
Tuna cages

Optical images (2.5m resolution)

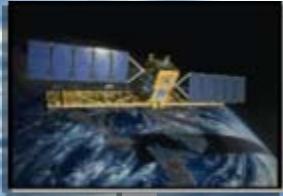


Aerial photo from Maltese inspection

SAR images (25m resolution)



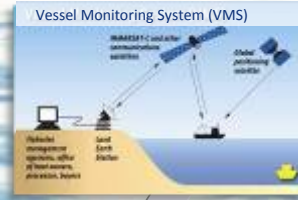
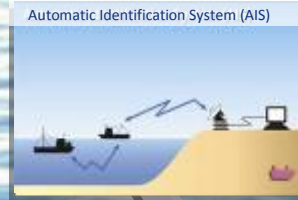
VDS (Vessel Detection System)



Satellite image acquisition



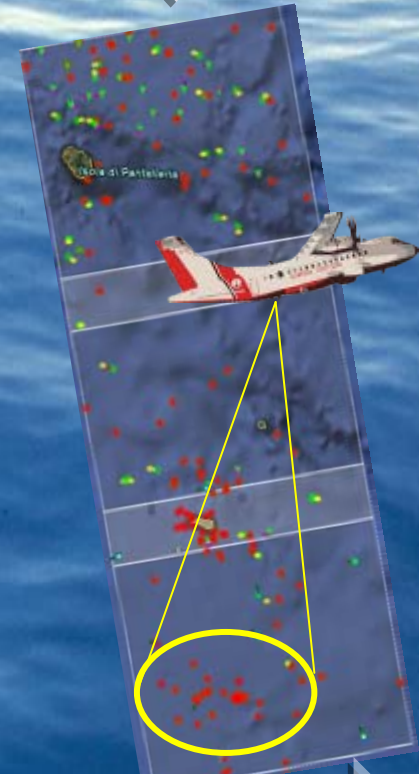
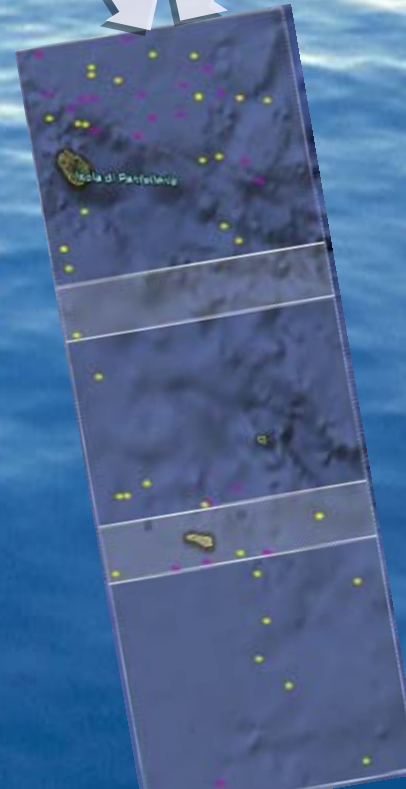
JRC's vessel detection software



Data fusion and reporting to inspectors

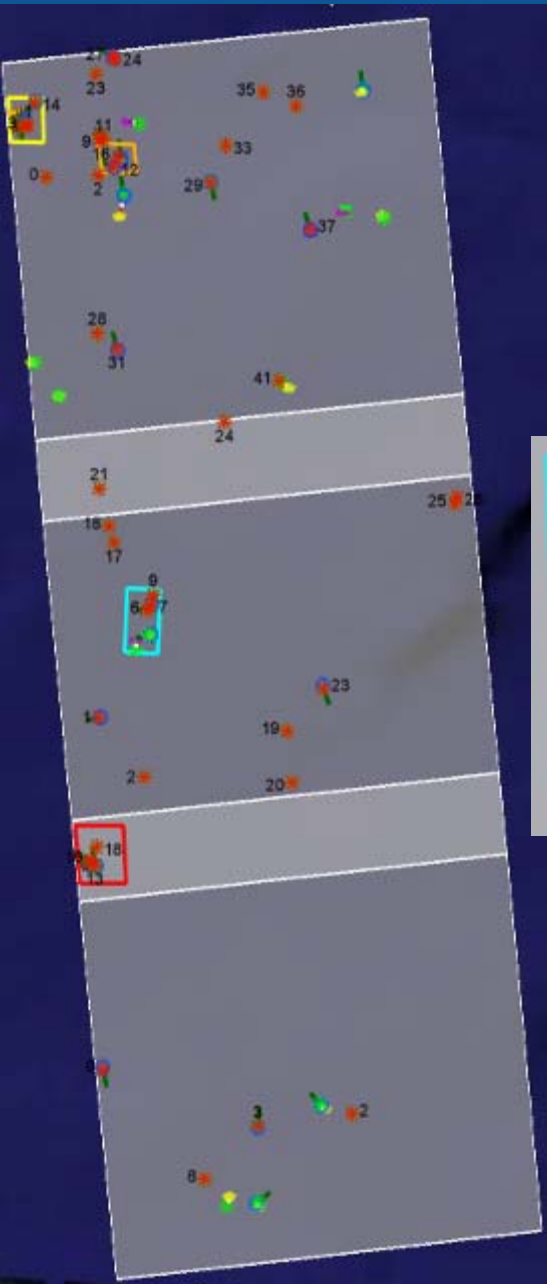


Reception of other positioning data

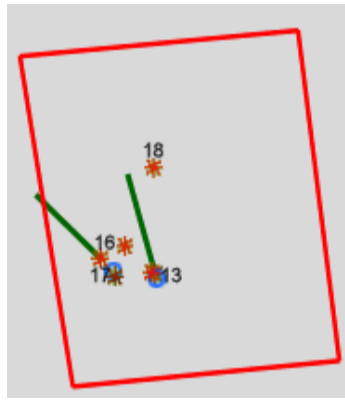


Total: 15-90 minutes

Identifying fishing and towing activity



Areas of interest



Can help to target inspection

Detection of vessels towing can help to estimate future positions, as:

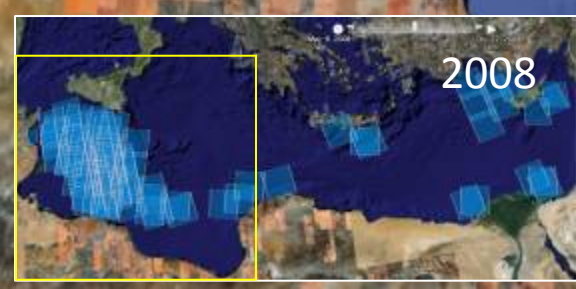
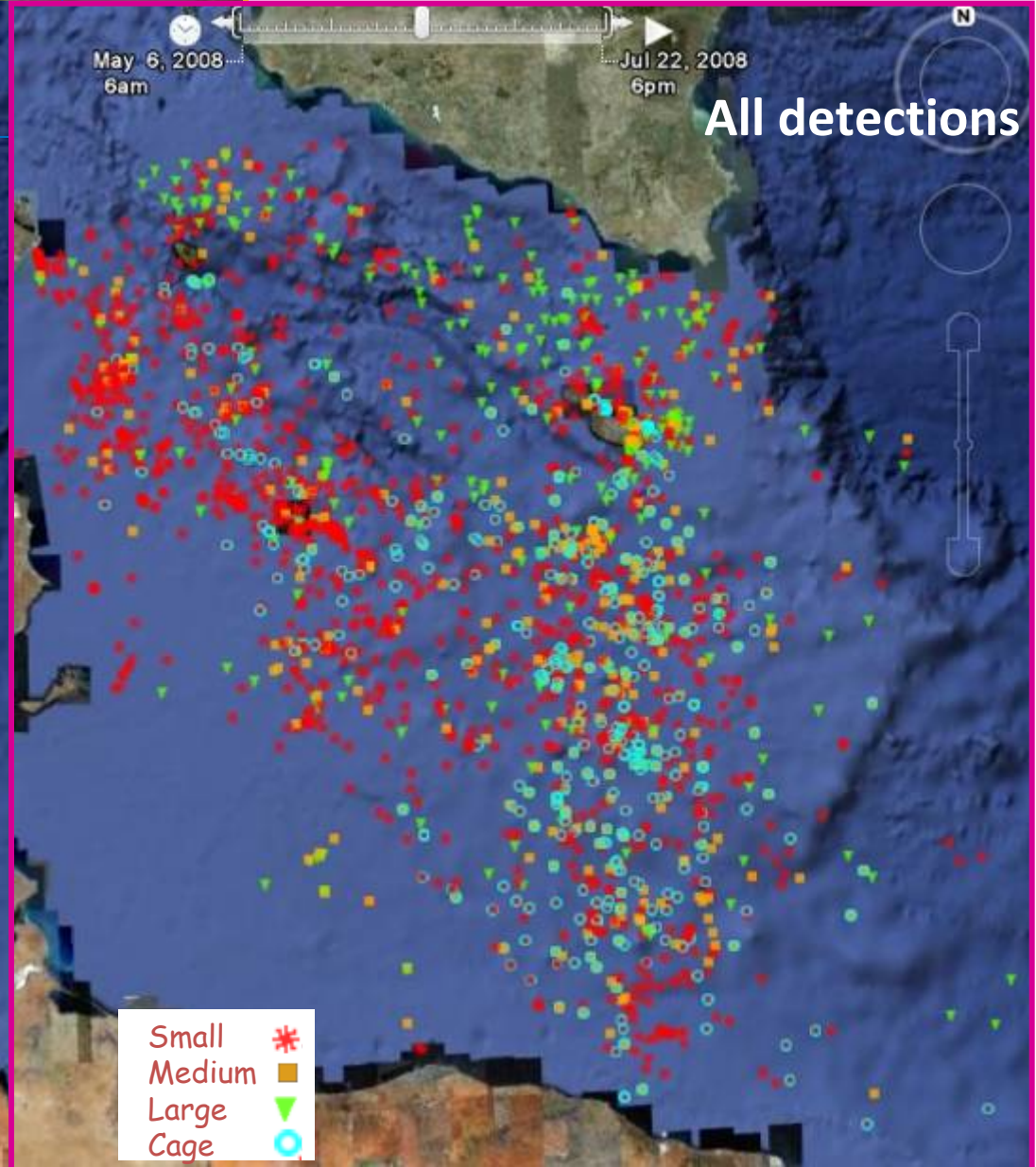
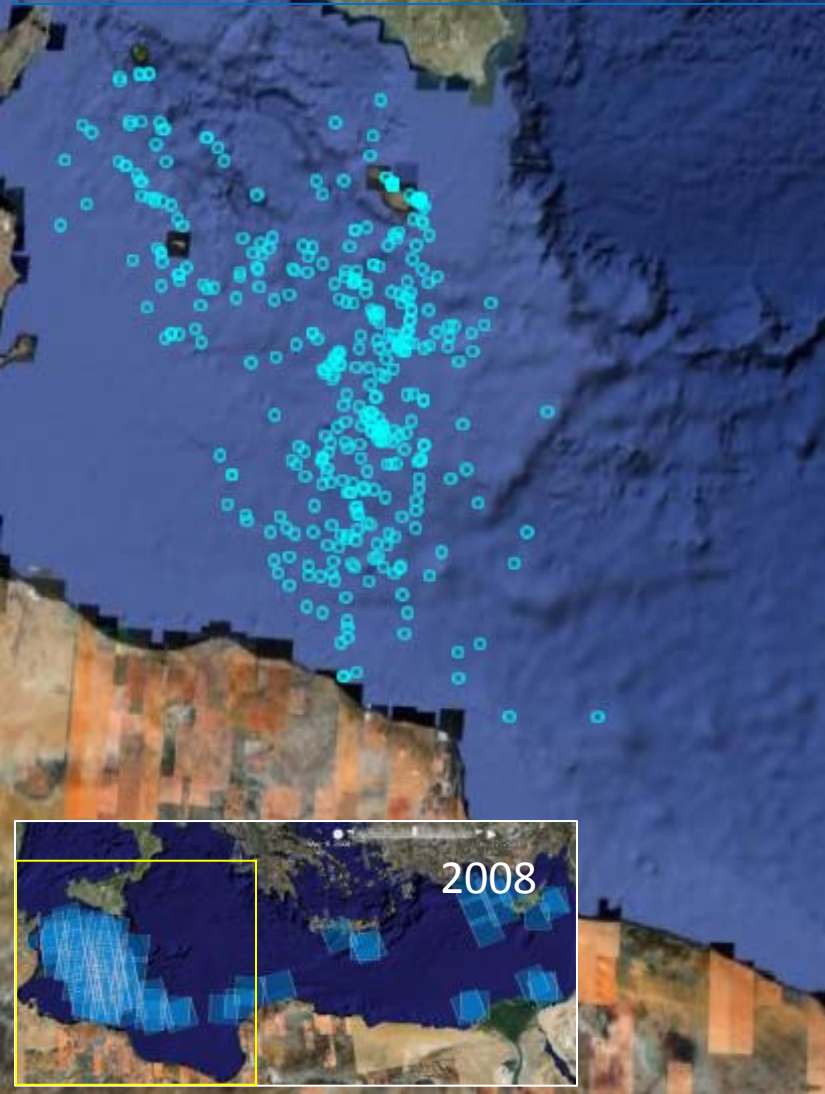
- the direction of towing can be estimated
- towing of cages is done very slowly (around 1 knots).



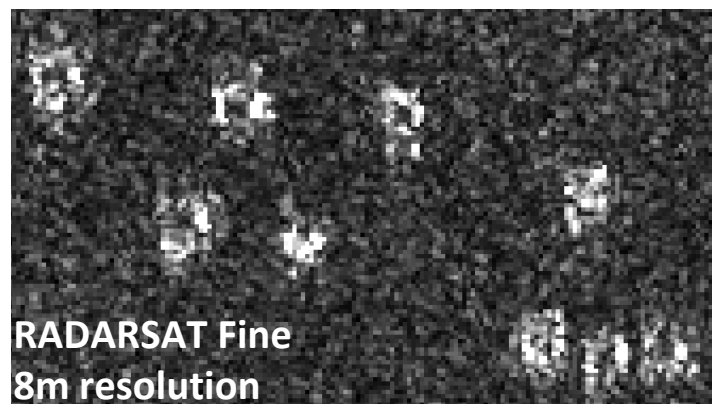
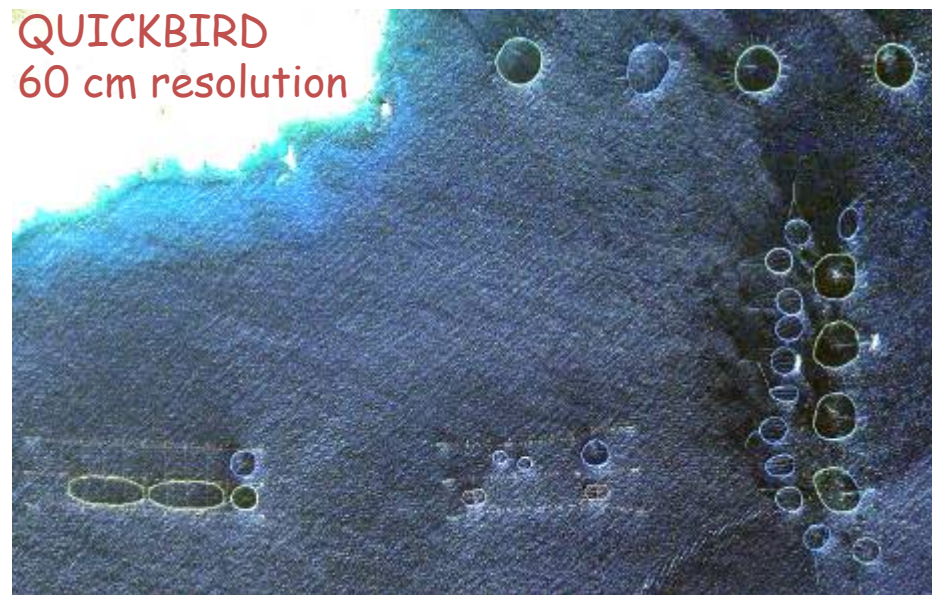
JRC 2008 Med BFT campaign



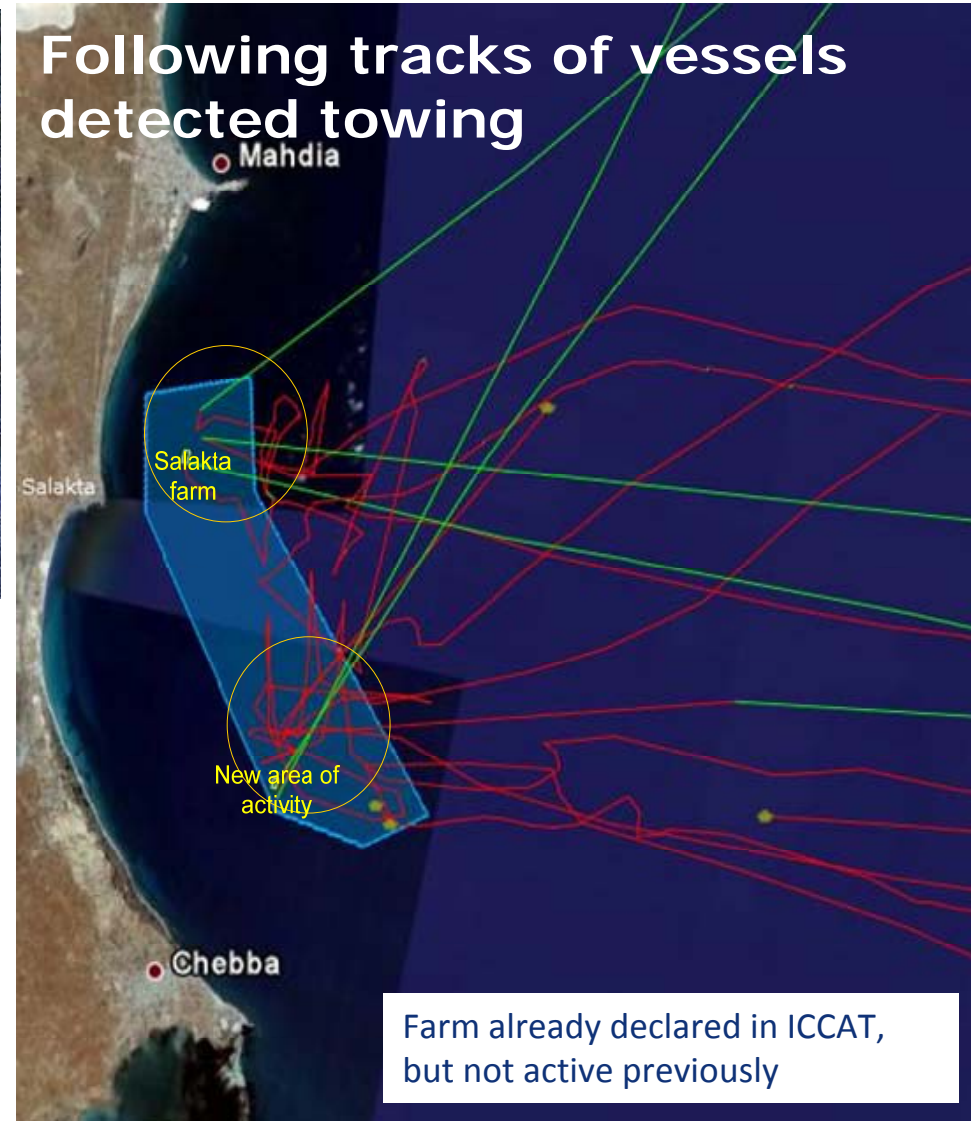
377 cages detected to be towed
in 95 images / 54 satellite passes



Identifying activity in BFT farms



Date

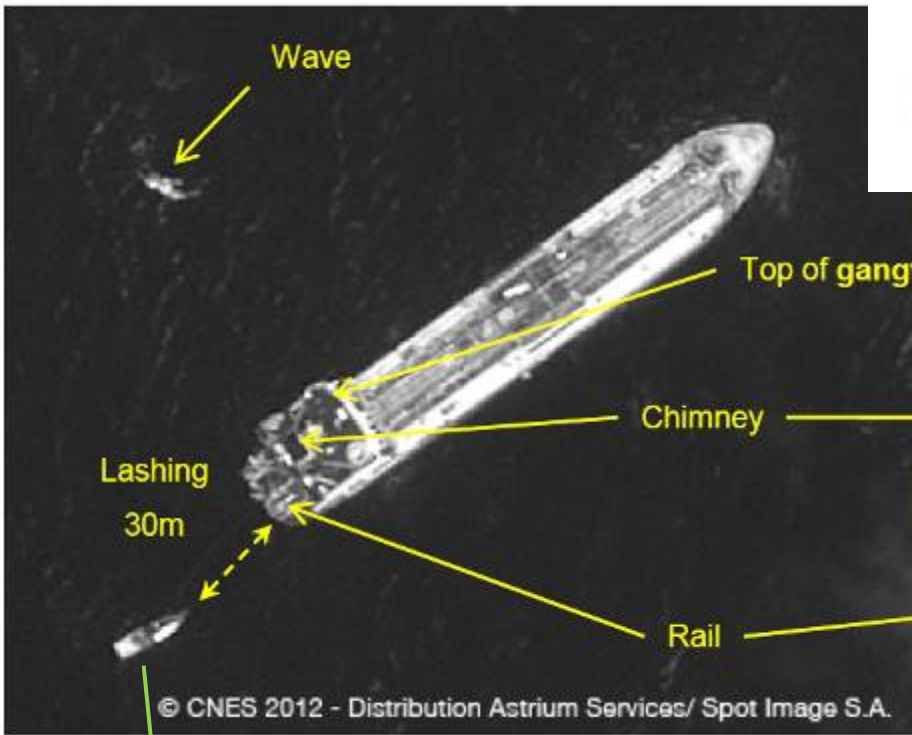
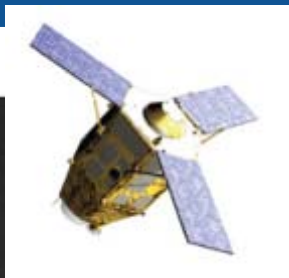


Footer

Pleiades-1 new optical satellite



launched Dec 2011



10 x 20 km swath
50 cm resolution

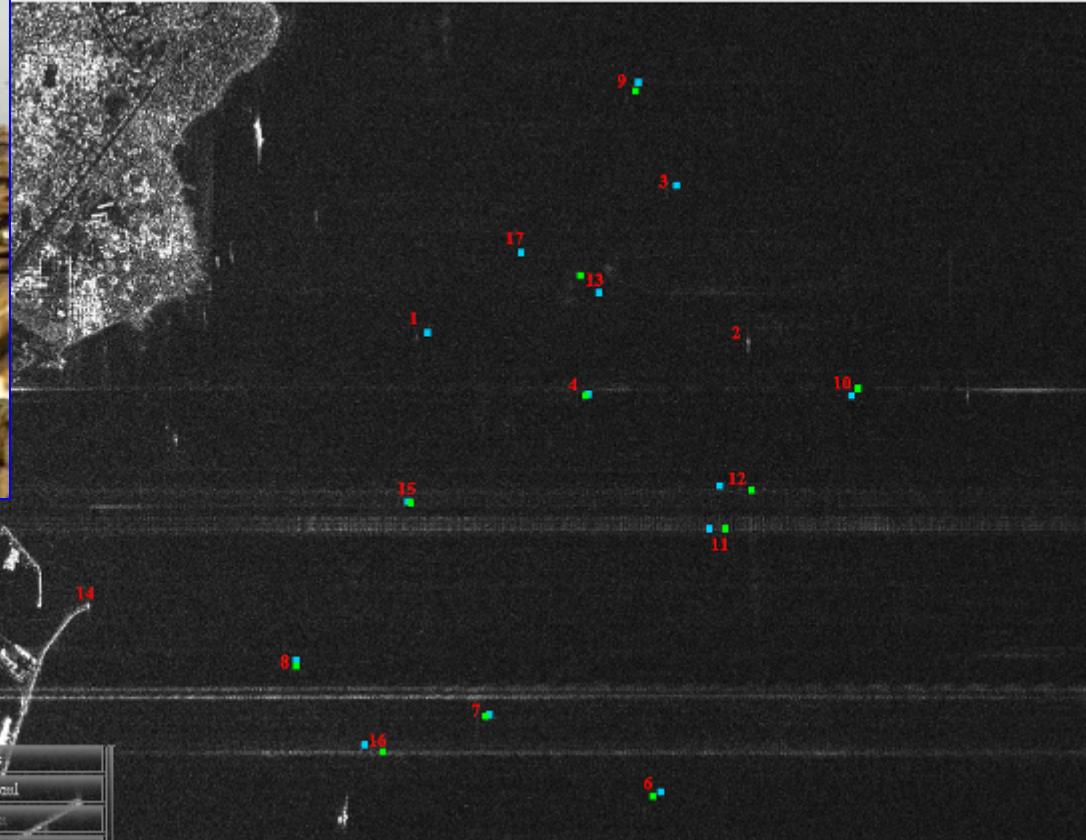


...but there are also optical satellites with 600 km swath and 22 m resolution (DEIMOS-1)

Trial for canoes monitoring



SUMO Application - Vessel Detection Software from the European Commission Joint Research Centre
System Help Analysis Import Tools



Layers
product.xml
Position
MSSIS UF 2011042 0
GpsCanoes UF 201104

USN SPAWAR + University of Ghana
-Class B AIS: to track from coastal
-Radar reflector: to detect in satellite SAR
-GPS logger: to know position afterward

Space-based surveillance limitations



- **No continuous monitoring possible, only periodic updates**
 - Sat-AIS: roughly every 6 hr now, will go down to sub-hourly
 - Sat images: roughly daily, but have to select area
- **Data are available with a delay**
 - Need to be downloaded to Ground Station, processed, sent to user
 - 2 hour – 15 min
- **Data have a cost**
 - Considering the information content, images are more expensive than AIS



Space-based surveillance limitations (II)



Sat imaging only:

- **Need to plan data request days in advance**
 - Select from available satellite overpass times
- **Choose between**
 - Wide area (300 km) – big ships (> 35 m)
 - ...
 - Small area (10 km) – small boats (> 5 m)
- **Ship identification not possible**
 - Detection, classification
 - Classification much easier with optical images (but clouds-limited)

Sat-AIS only:

- **Don't find not-reporting vessels**

- *Low-resolution multispectral imagers on satellites*
- *Daily coverage but limited by cloud cover*



Potential feeding habitat

- *Identified with the simultaneous occurrence of oceanic fronts of temperature [SST] and chlorophyll [CHL-a], based on literature*

Potential spawning habitat

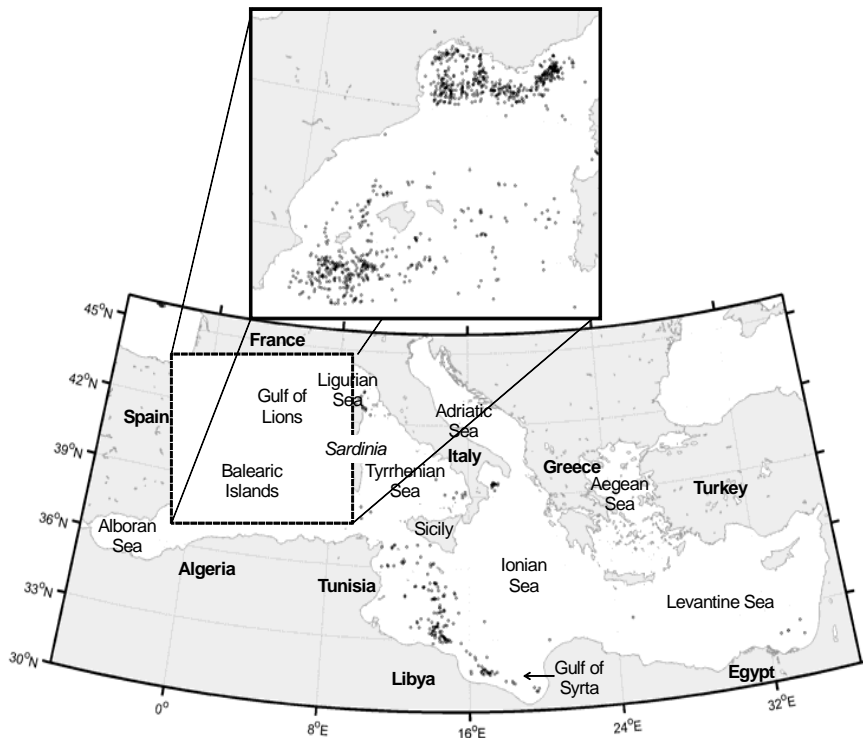
- *Revealed from a mean surface temperature increase over 30 days*
- *Almost no relevant literature except minimum temperature threshold*
- *Known spawning grounds are retrieved*

ABFT Habitat How?

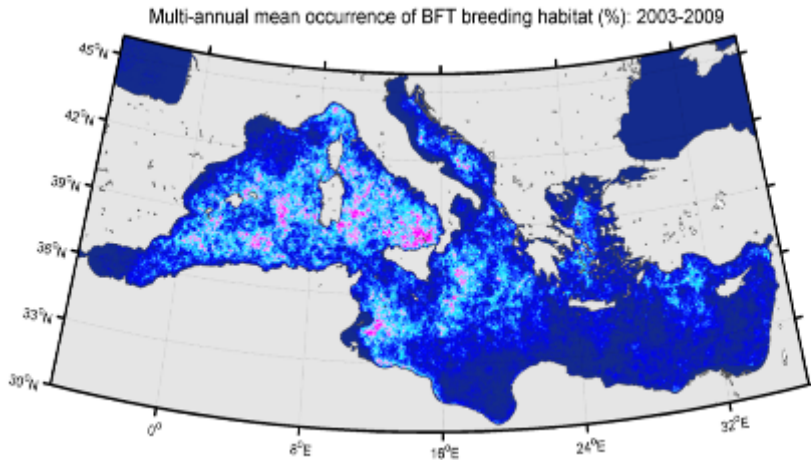


Daily data of SST and CHL-a from MODIS-AQUA (2002-now), MODIS-TERRA and SeaWiFS (2000-2010) (4.6 km)

Precisely located observations (presence data) of ABFT a priori in both habitats for the calibration/validation.



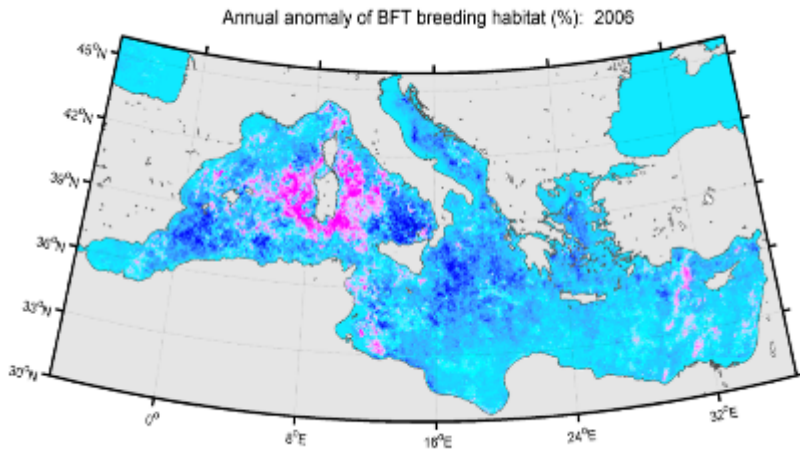
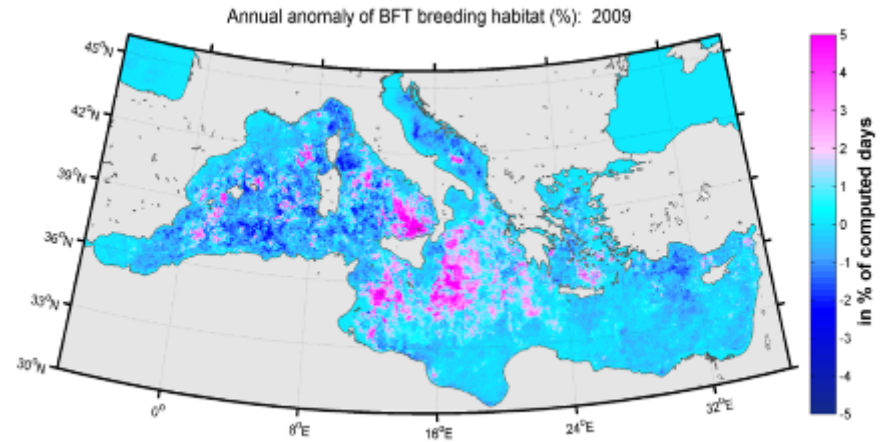
Multi-annual spawning habitat & anomalies



European
in % of computed days
(blank = % of days computed < 28% of total days)

Main potential spawning grounds of bluefin tuna (2003-2009)

2009: Spawning anomaly in the Central Mediterranean Sea



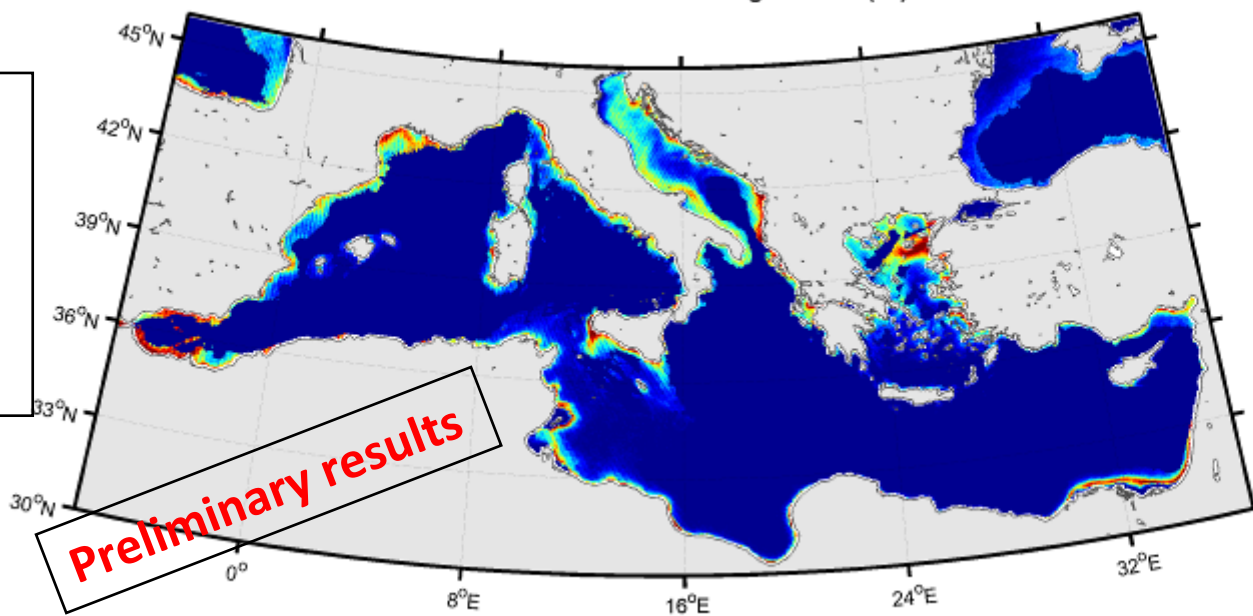
in % of computed days

2006: Spawning anomaly around Sardinia

*Hake potential
habitat (feeding) –
Mediterranean Sea*



Summer occurrence of HAKE feeding habitat (%): 2003-2012



70
60
50
40
30
20
10
in % of computed days
(blank = % of days computed < 6% of total days)

**Summer
potential
habitat of
juvenile hake
(2003-2011)**

**Essential Habitat
for hake
(de Juan 2010)**

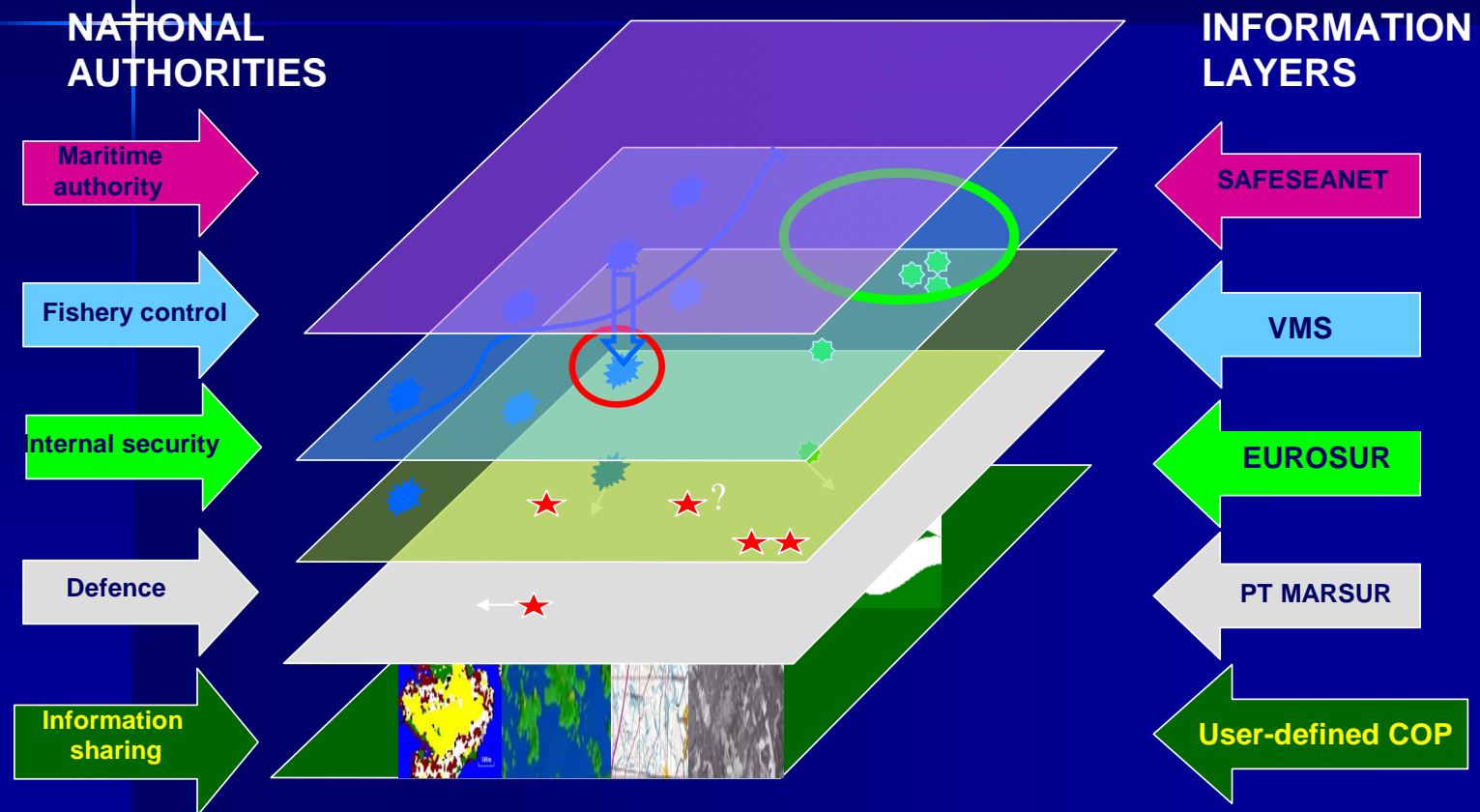


CISE – for the maritime domain



Part of EU's Integrated Maritime Policy

COMMON INFORMATION SHARING ENVIRONMENT



- **In addition to VMS, also AIS is useful**
 - Tugs, reefers, fishing vessels
 - International sharing networks
 - Satellite-AIS away from coast (many new sats)
 - **Satellite images to find non-reporting ships**
 - Match image size / detail to fisheries type (radar)
 - Optical for high resolution and farms
 - Combine sat images with reporting data (many sats)
 - **Ocean colour and SST for habitat mapping**
 - Feeding areas, spawning areas
- **Plan control measures and control campaigns considering using these possibilities**



Joint Research Centre (JRC)

www.jrc.ec.europa.eu

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