An autonomous imaging system for Argo-Floats

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TISANA: **T**est study of an **I**maging **S**ystem for **A**rgo floats: detecti**N**g jellyfish in a frontal **A**rea

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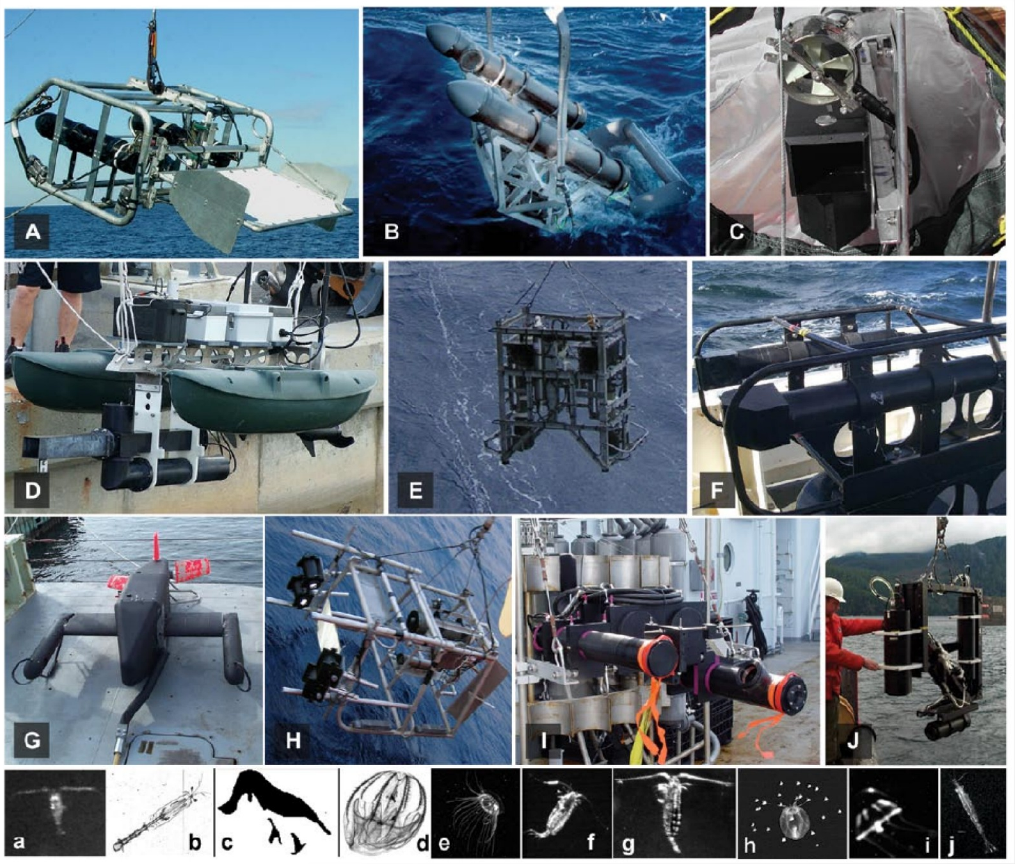
Motivation

- Many imaging devices are designed to be towed by support vessels or to be installed on cabled observatories

- the power needed for their functioning, including the lighting system, is assured by cables
- the acquired data are transferred through cables
- the video/image processing is performed outside the acquisition device



Benfield 2007

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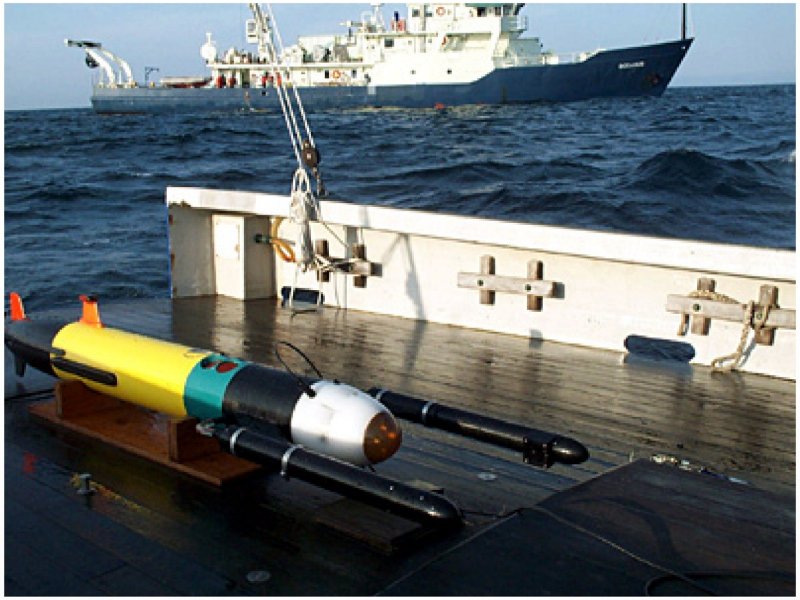
Motivation

- Other imaging devices are designed to be installed on board on AUV
- Short deployments and/or expensive vehicles
- In many cases data are downloaded and processed after the vehicle recovery



UVP on REMUS, *Haystead 2000*

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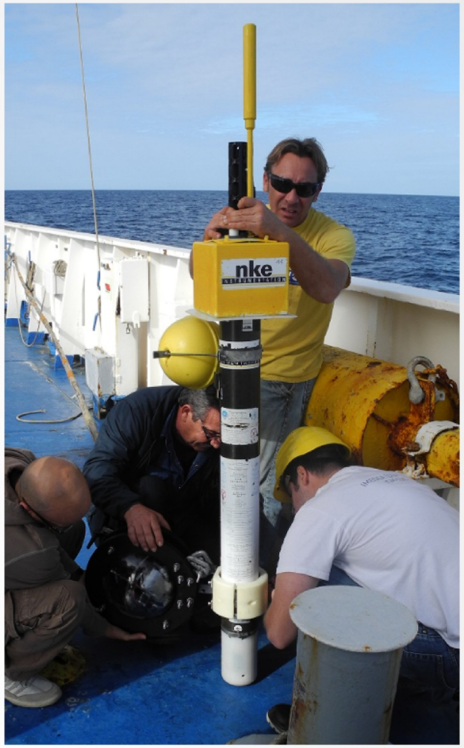
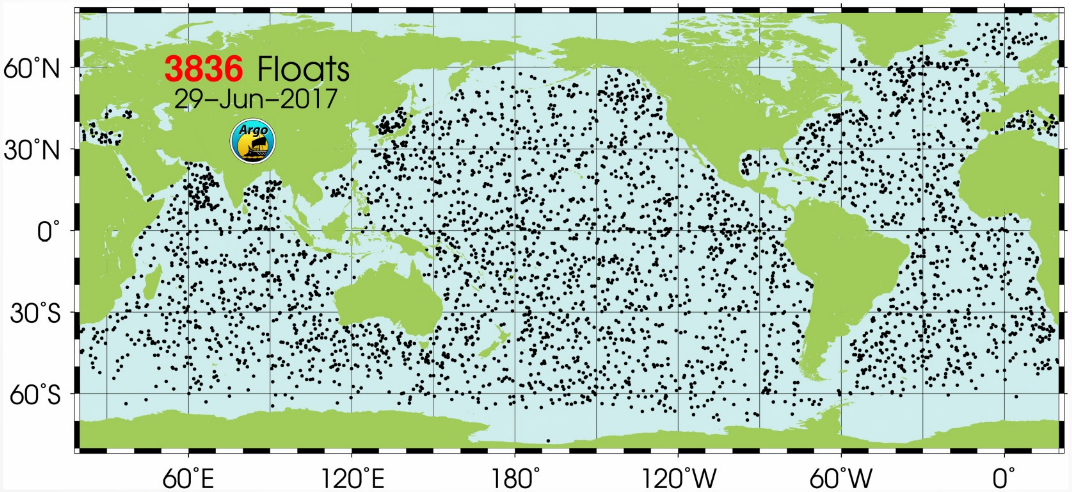
GUARD1 Imaging Device

- Stand-alone (not wired) and autonomous (unmanned) programmable device, capable to acquire and process underwater images and transmit the information extracted from the acquired images (European Patent EP 2863257- Underwater images acquisition and processing system)
- The device has been conceived for long lasting deployments
- The acquired images are processed on board the device with the aim of extracting relevant information (e.g. recognition and classification of gelatinous zoo-plankton or fish specimens)
- The information extracted form the images is transmitted outside the device (e.g. textual information, image regions)



GUARD1 on ARVOR I
TISANA project



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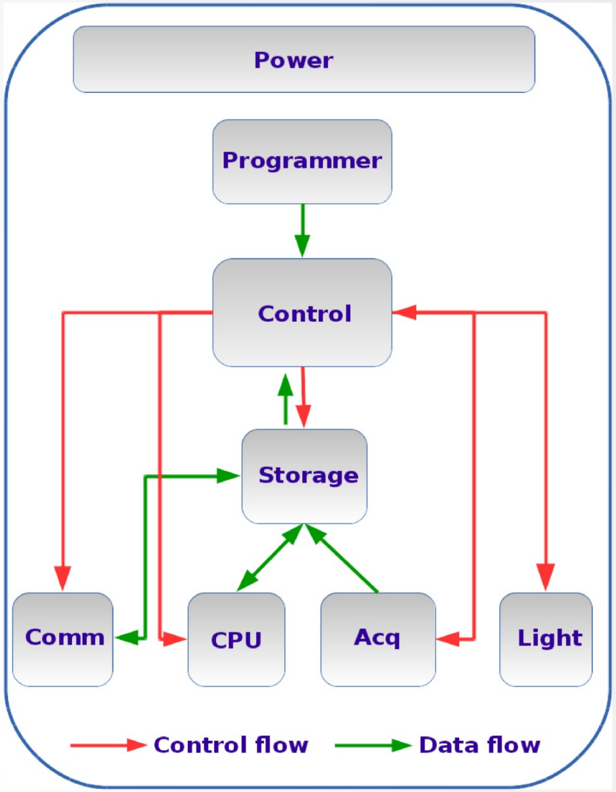
GUARD1: Hardware Components

- **Acquisition component**:
  - The current prototype is based on a commercial camera equipped with an appropriate firmware
  - A CMOS sensor controlled by a FPGA is in the process of development
- **Lighting System**: array of high efficiency LEDs
- **Processing Unit**: runs the image processing and communication algorithms
- **Communication component**:
  - Experiments were performed with either acoustic or satellite modems



- **Control component**: It is programmable and manges the image acquisition frequency, the lighting system, the image processing unit and the communication component

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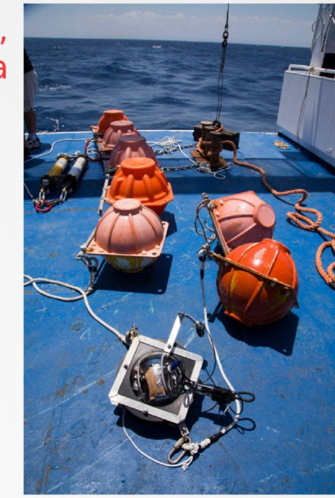
GUARD1: power consumption

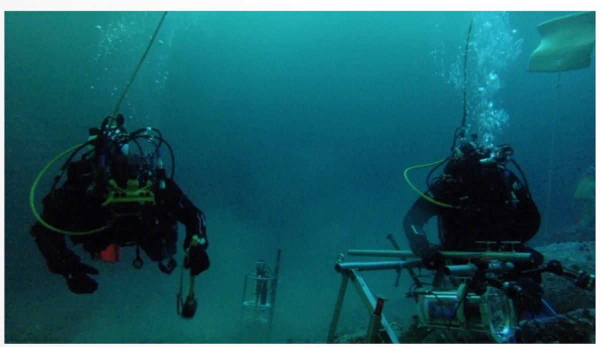
- Many tests were performed in order to:
  - identify the best acquisition parameter set-up;
  - acquire data for training the recognition algorithms
  - estimate the average power consumption
- On average the device absorbs 0.016 W per image

Oceanographic Mooring, Tyrrenian Sea



Application Example based on the current prototype (commercial camera):

- A battery pack of 35Ah, 10.8V (3 Tadiran batteries 3.6V) allows for ~23600 images
- One image every 10 minutes allows for a deployment extended for 5.5 months



Tethys Bay, Ross Sea, Antarctica

Acqua Alta Oceanographic Platform, Adriatic Sea

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GUARD1: Image Processing

- Each time the Image Processing Unit is turned on, it processes a bunch of images per time
- Since the hardware has a limited capacity, very low computational complexity algorithms must be used
- Computer Vision algorithms are used to identify regions of image that contain relevant information (RoI)
- Pattern Recognition algorithms recognize/classify the RoI content
- The information extracted form the images is encoded as textual data

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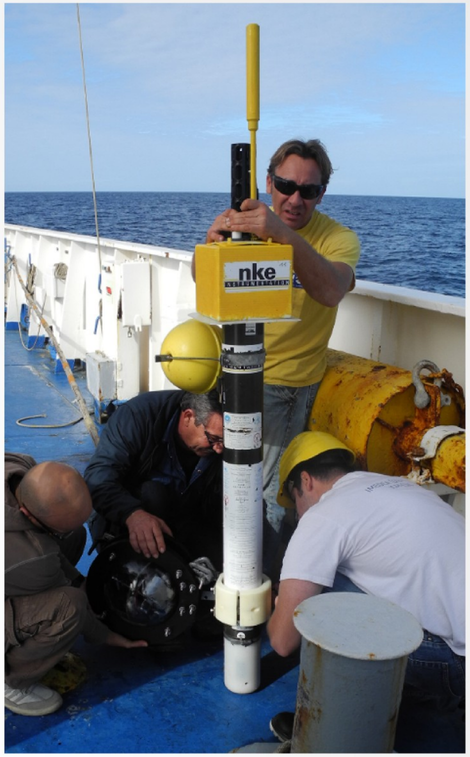
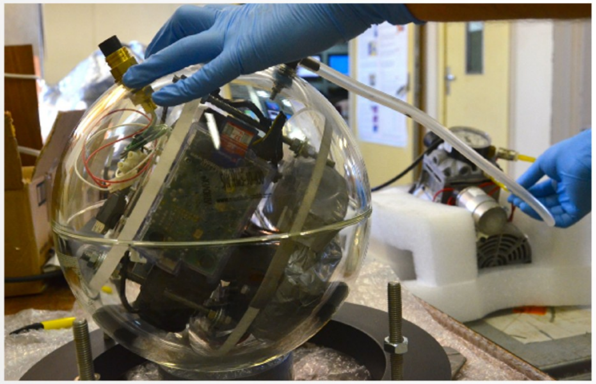
GUARD1 & Argo Float

- The GUARD1 was configured only for image acquisition and storage
- A glass sphere (25 cm diameter) was used for the GUARD1 housing (included the battery pack)
- Deep sea electrical connector was used for powering the lighting system, placed outside the sphere
- Ad-hoc clamps were used to mechanically connect the glass sphere to the ARVOR I Argo Float
- Lead ballast and a buoy were used for obtaining a neutral buoyancy of the GUARD1 system (glass sphere, clamps)





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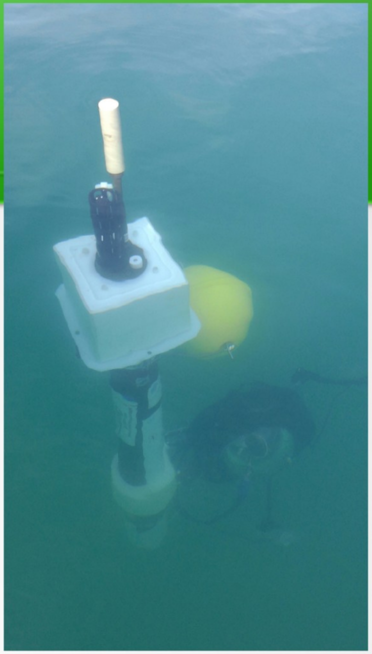
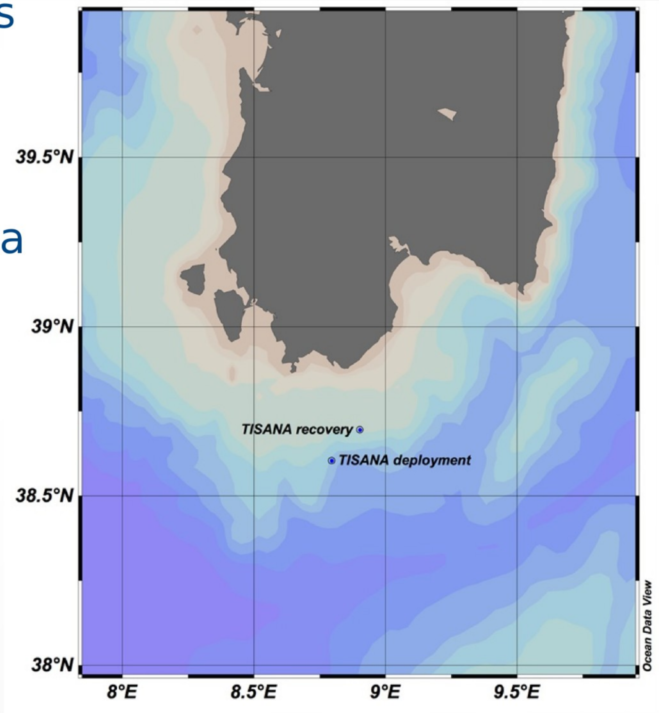
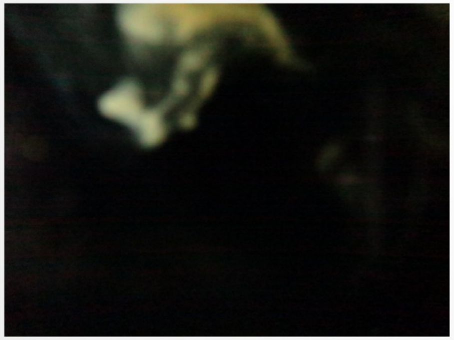
GUARD1 & Argo Float



- Several tests were performed in shallow water (Ligurian sea) for assessing the acquisition component, the lighting system and the system buoyancy
- A deployment (and recovery) was performed south of Sardinia
- Three cycles were performed, about 24 hours each, with a max depth of 300m depth
- One image acquired every 2 minutes for a total of 4020 images
- The majority of the acquired images were empty (black)
- Several gelatinous organisms (???) were captured in the water column and some floating object were captured close to the sea surface





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GUARD1 & Argo Float

<u>Critical issues</u>:

- The GUARD1 volume must be reduced in order to reduce the impact of the water density gradient on the system (Argo Float + GUARD1)
- The buoyancy range of the Float was unknown
- The Integration between the Float and the GUARD1 should strongly reduce the system volume
- A more flexible duration of the Float cycle should be needed for performing more accurate system tests
- Light absorption in the water column strongly affects the image quality, thus the lighting system must be optimized

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GUARD1: On going activities

The communication component is in the process of integration for the Argo Float applications:

- A PICO 96063 SBD Iridium transceiver is used for transmitting the information extracted from the acquired images
- An Iridium antenna has been appropriately modified (resin encapsulation) in order to be used at 2000m depth

- An appropriate wet/dry sensor for detecting when the float reaches the sea surface has been designed and developed
- The electrical connector of the glass sphere has been modified in order to power the lighting system, to transfer the information from/to the antenna and from the wet/dry sensor

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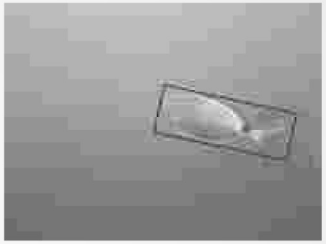
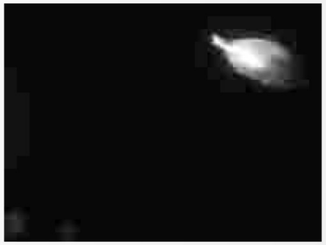
GUARD1: On going activities

Several transmission tests have been performed from the lab:

- The SBD Iridium protocol transfers 240 Bytes per message
- The PICO 96063 transceiver
  - opens a SBD session (from 20s to few minutes depending on the signal quality)
  - transmits the buffered SBD messages ($\sim 10^{-1}$s per message)
  - closes the SBD session
- **Text data Transmission:**
  - Each image has a time-stamp, thus time-series consisting of <time-stamp, number of specimens> can be transmitted
- **Image data Transmission:**
  - Images (or RoIs) must be scaled and downgraded (e.g. jpeg compression protocol)
  - The two example images need 2.5 and 3.2 SBD messages to be transmitted



200x150 pixels
jpg quality = 10
610 Bytes



200x150 pixels
jpg quality = 10
789 Bytes

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Future Work

- New tests and experiments by using the communication component will be performed
- A new acquisition component based on a CMOS sensor controlled by FPGA and a hardware-level image recognition filter are currently under development

- Integration of the battery pack and of the communication component into the Argo Float should strongly decrease the system volume
- The integration between the GUARD1 and the Argo Float would allow for interaction between the imaging device and the Float e.g. the Float could follow a swarm of jellyfishes

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Questions?

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