SPYGEN. OCEANS

SANTA MARIA MANUELA · AZORES 2026

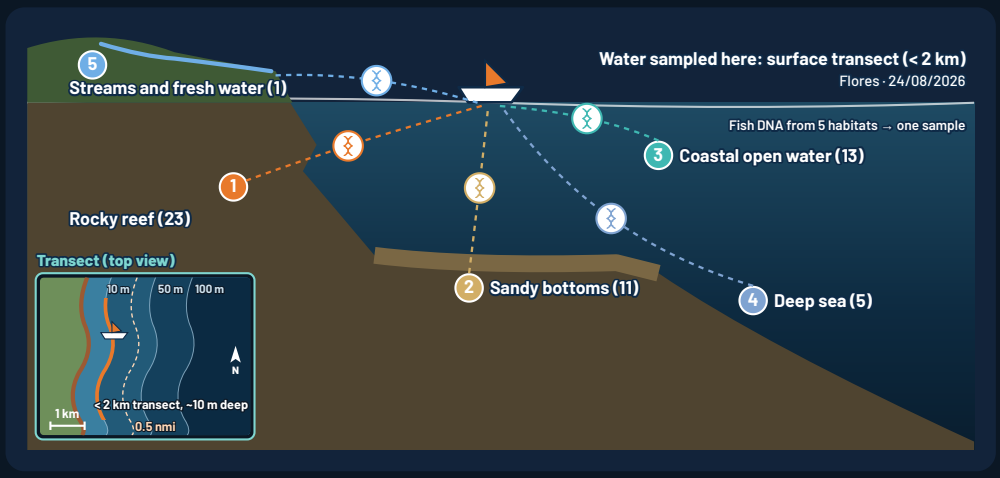


Santa Maria Manuela tall ship · Photo: Bernardo Aires

# One water sample, 53 fishes and rays identified

On 24 August 2026 we filtered seawater off the rocky coast of Flores. No nets, no catches, no dive counts: only the DNA that animals shed into the water. We sampled only the surface, yet that water carried DNA from fish living on the rocky reef, on the seabed, in open water and in the deep. Here is what that single sample tells us.

## Sampling site




Schematic cross-section of Flores. Water was filtered along a surface transect of less than 2 km running parallel to the coast, less than 0.5 nautical miles from shore, over about 10 m of water. DNA arrives from several habitats, carried by currents and by animals moving through the water column. Dashed lines show DNA from each habitat reaching the surface sample. Inset: top view of the transect along the coast, with depth contours and the 0.5 nmi line (schematic, not to scale).

- 1 · Rocky reef 23
- 2 · Sandy bottoms 11
- 3 · Coastal open water 13
- 4 · Deep sea 5
- 5 · Streams and fresh water 1

## Results at a glance

Although this was a small surface sample of about 25 litres, it picked up fish from all five habitats shown above, from rocky-reef dwellers to sandy-bottom species, open-water shoals, deep-sea lanternfishes and even a freshwater-linked eel.

**53**
fish taxa detected in a single sample, across 34 families

**41**
identified to species; the remaining 12 to genus or family

**4**
elasmobranch taxa, including the smooth hammerhead

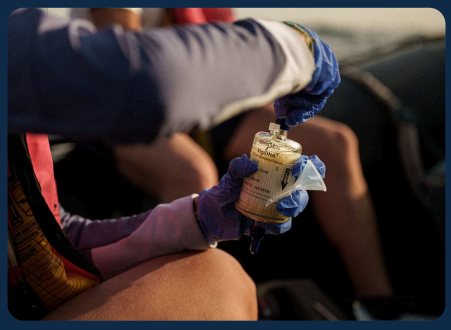
### Who leaves the most DNA in the water

DNA copies per litre, the five species with the strongest signal

| | |
|---|---|
| white seabream | 13692 |
| parrotfish | 8767 |
| black-faced blenny | 7427 |
| brown moray | 5248 |
| curled picarel | 4317 |

## How we work

Three key elements make the eDNA protocol robust and reliable.


Filtering on board a dinghy with a peristaltic pump and a 0.2 µm VigiDNA® sampling capsule. Photos: Bernardo Aires.

01

### Sampling strategy

- High-capacity filters
- Up to 30 litres of water per filter
- Transect-based sampling (here: under 2 km at the surface, in coastal areas)

02

### PCR replicates

- 12 replicates per sample
- High-performance primers (Teleo marker, fish)

The DNA from each sample is amplified 12 times, independently. Repeating the PCR increases the chance of detecting rare species, whose DNA is present at very low concentrations.

03

### Sequencing depth

- **Marine fish:** up to 1M reads

Sequencing depth is the number of DNA sequences read for each sample. Reading around one million sequences per sample means that rare species are picked up alongside the dominant ones, instead of being drowned out by them.

Identification against public and proprietary reference databases (minimum 98 % identity). Semi-quantification by dPCR, in DNA copies per litre.

## What these species tell us

The species list is the starting point. Crossed with conservation status, fisheries use and ecology, it becomes information for management.

### Threatened species

We detected species listed as Vulnerable on the global IUCN Red List, without having to see or catch them.

- *Sphyrna zygaena*, smooth hammerhead · 4 copies/L VU (IUCN 2019)
- *Epinephelus marginatus*, dusky grouper · 78 copies/L VU
- *Dasyatis pastinaca*, common stingray · 6 copies/L VU
- *Balistes capriscus*, grey triggerfish · 2502 copies/L VU
- *Pomatomus saltator*, bluefish · 184 copies/L VU

### Sharks and rays

Four elasmobranch taxa, a group that is hard to record with visual surveys.

- *Sphyrna zygaena*, smooth hammerhead · 4 copies/L VU (IUCN 2019)
- *Dasyatis pastinaca*, common stingray · 6 copies/L VU
- *Dasyatis* sp., stingray · 5 copies/L
- *Taeniurops grabatus*, round fantail stingray · 30 copies/L

### Notable regional species

The list includes the black moray, one of six Macaronesian endemic fish species found in all the archipelagos (Freitas et al. 2019), and *Scorpaenodes arenai*, a rare scorpionfish known only from the Azores and the Mediterranean (Catalog of Fishes; Italian Journal of Zoology, 2015):

- *Muraena augusti*, black moray · 2585 copies/L
- *Scorpaenodes arenai*, scorpionfish · 25 copies/L

### Fishery resources

A good part of the list has commercial value, which links biodiversity directly to local fisheries:

- *Sardina pilchardus*, European pilchard · 1 407 copies/L
- *Trachurus* sp., horse mackerel · 259 copies/L
- *Scomber colias*, Atlantic chub mackerel · 67 copies/L
- *Pagellus acarne*, axillary seabream · 11 copies/L
- *Phycis phycis*, forkbeard · 60 copies/L
- *Pomatomus saltator*, bluefish · 184 copies/L VU
- *Mullus surmuletus*, striped red mullet · 106 copies/L
- *Belone belone*, garfish · 280 copies/L

### Signals from the deep

Mesopelagic fishes turned up in a coastal sample, probably through vertical migration, currents and the deep slopes close to Flores:

- *Malacosteus niger*, stoplight loosejaw · 34 copies/L
- *Myctophum punctatum*, spotted lanternfish · 22 copies/L
- *Ceratoscopelus maderensis*, Madeira lanternfish · 5 copies/L
- *Bolinichthys* sp., lanternfish · 100 copies/L
- *Himantolophus* sp., footballfish · 7 copies/L

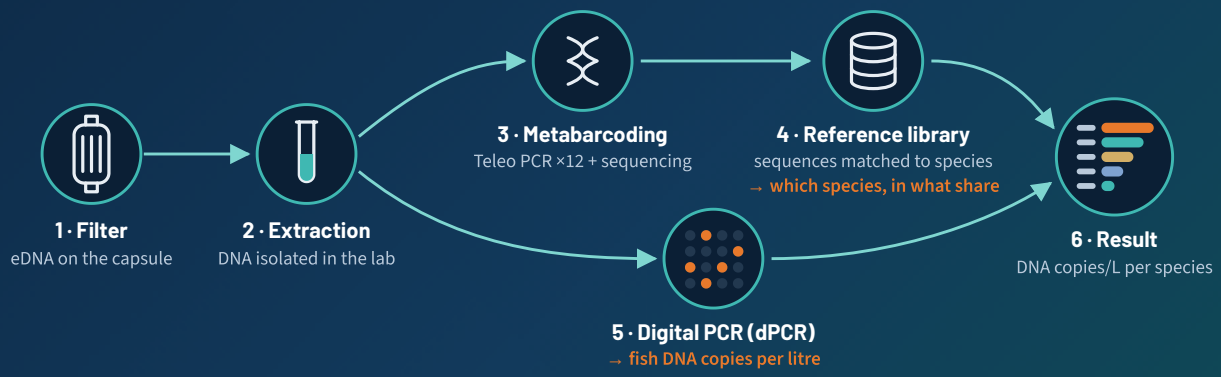
### Confirmed by a visual record

Five of these detections were also recorded visually at the same site during a recreational dive. This visual record confirms the eDNA results.

- *Sphyrna zygaena*, smooth hammerhead · 4 copies/L VU (IUCN 2019)
- *Sphyraena viridensis*, yellowmouth barracuda · 5 copies/L
- *Diplodus vulgaris*, two-banded seabream · 74 copies/L
- *Labrus* sp., wrasse · 872 copies/L
- *Sparisoma cretense*, parrotfish · 8 767 copies/L

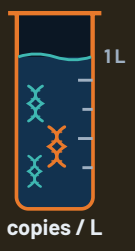
## From water to results

What happens to the sample between the boat and the report.




### How to read these results

**What are DNA copies per litre?** They are a semi-quantification proxy, measured with digital PCR (dPCR): the number of copies of each species' DNA per litre of filtered water. Because they take into account the volume of water filtered, they can be compared between sites, seasons and years, which the relative proportions of sequences alone do not allow. They are an abundance proxy, not a count of individuals: the signal also depends on distance to the source, behaviour and DNA degradation.




### Sharks and rays: weak DNA signal, confirmed presence

Sharks and rays tend to leave weak eDNA signals: with skin covered in denticles and less mucus, they are thought to release less DNA into the water than bony fishes. The smooth hammerhead shows why this matters: only 4 copies/L, yet the day after sampling at least eight individuals were recorded visually during a recreational dive close to where the water was collected. Detecting it from a single 25-litre surface sample shows the power of the SPYGEN protocol, even for species that release very little DNA into the water. A less robust protocol may have missed them.

# All 53 detections, by habitat

DNA copies per litre for each taxon, grouped by main habitat. Bars use a logarithmic scale so that weak detections stay visible; the exact value is on the right. VU = Vulnerable (IUCN Red List). SEEN DIVING = also recorded visually at the site during a recreational dive.

## 1 · Rocky reef — 23 taxa

| | |
|---|---|
| white seabream<br>*Diplodus cadenati* | 13692 |
| parrotfish SEEN DIVING<br>*Sparisoma cretense* | 8767 |
| black-faced blenny<br>*Tripterygion delaisi* | 7427 |
| brown moray<br>*Gymnothorax unicolor* | 5248 |
| salema<br>*Sarpa salpa* | 3728 |
| ornate wrasse<br>*Thalassoma pavo* | 2750 |
| black moray<br>*Muraena augusti* | 2585 |
| grey triggerfish VU<br>*Balistes capriscus* | 2502 |
| wrasse SEEN DIVING<br>*Labrus* sp. | 872 |
| cardinalfish<br>*Apogon imberbis* | 643 |
| rainbow wrasse<br>*Coris julis* | 596 |
| blenny<br>*Lipophrys trigloides* | 520 |
| goby<br>*Gobius* sp. | 214 |
| shore rockling<br>*Gaidropsarus mediterraneus*<br>*G. guttatus* is a junior synonym (Catalog of Fishes) | 172 |
| blenny<br>*Parablennius incognitus* | 170 |
| sea chub<br>*Kyphosus* sp. | 160 |
| dusky grouper VU<br>*Epinephelus marginatus* | 78 |
| two-banded seabream SEEN DIVING<br>*Diplodus vulgaris* | 74 |
| forkbeard<br>*Phycis phycis* | 60 |
| Mediterranean moray<br>*Muraena helena* | 31 |
| scorpionfish<br>*Scorpaenodes arenai* | 25 |
| swallowtail seaperch<br>*Anthias anthias* | 22 |
| gobies<br>Gobiidae | 8 |

## 3 · Coastal open water — 13 taxa

| | |
|---|---|
| curled picarel<br>*Centracanthus cirrus* | 4317 |
| bogue<br>*Boops boops* | 3859 |
| European pilchard<br>*Sardina pilchardus* | 1407 |
| thicklip grey mullet<br>*Chelon labrosus* | 1332 |
| garfish<br>*Belone belone* | 280 |
| horse mackerel<br>*Trachurus* sp. | 259 |
| bluefish VU<br>*Pomatomus saltator* | 184 |
| pompano<br>*Trachinotus ovatus* | 103 |
| Atlantic chub mackerel<br>*Scomber colias* | 67 |
| white trevally<br>*Pseudocaranx dentex* | 21 |
| frigate tuna<br>*Auxis* sp. | 17 |
| yellowmouth barracuda SEEN DIVING<br>*Sphyraena viridensis* | 5 |
| smooth hammerhead VU SEEN DIVING<br>*Sphyrna zygaena* | 4 |

## 2 · Sandy bottoms — 11 taxa

| | |
|---|---|
| Guinean puffer<br>*Sphoeroides marmoratus** | 214 |
| conger eel<br>*Paraconger macrops* | 111 |
| striped red mullet<br>*Mullus surmuletus* | 106 |
| gurnards<br>Triglidae | 40 |
| cusk-eel<br>*Parophidion* sp. | 37 |
| round fantail stingray<br>*Taeniurops grabatus* | 30 |
| axillary seabream<br>*Pagellus acarne* | 11 |
| common stingray VU<br>*Dasyatis pastinaca* | 6 |
| Atlantic lizardfish<br>*Synodus saurus* | 5 |
| stingray<br>*Dasyatis* sp. | 5 |
| wide-eyed flounder<br>*Bothus podas* | 3 |

## 4 · Deep sea — 5 taxa

| | |
|---|---|
| lanternfish<br>*Bolinichthys* sp. | 100 |
| stoplight loosejaw<br>*Malacosteus niger* | 34 |
| spotted lanternfish<br>*Myctophum punctatum* | 22 |
| footballfish<br>*Himantolophus* sp. | 7 |
| Madeira lanternfish<br>*Ceratoscopelus maderensis* | 5 |

## 5 · Streams and fresh water — 1 taxa

| | |
|---|---|
| eel<br>*Anguilla* sp.<br>Catadromous: grows in fresh water and migrates to the sea to spawn | 11 |

Santa Maria Manuela, Azores · sample collected on 24/08/2026 (Flores). SPYGEN analysis: Teleo marker, 12 PCR replicates, public and proprietary reference databases. Conservation status: IUCN Red List.