The following supplement accompanies the article

Monitoring marine populations and communities: methods dealing with imperfect detectability

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Aquatic Biology 16: 31–52 (*2012*)

Supplement: Comparison of Plot Sampling methods, and pictures demonstrating the application of methods, techniques and tools for monitoring marine populations and communities (including Plot Sampling, which ignores detectability issues, and methods that account for imperfect detectability, such as Distance Sampling, Repetitive Surveys for Occupancy Estimation, and Mark-Recapture; various techniques and tools are demonstrated herein for underwater, shipboard and aerial surveys)

Table S1. Comparison among devices and methods for monitoring marine populations and communities with plot sampling. ROV: remotely operated vehicle

Device	Target populations	Efficiency	Accuracy/resolution	Bias	Comment
Grabs	Endobenthos	Can be influenced by the penetration depth of the gear, weight of the gear, 'bite' profile, sediment type and the subsequently sampled volume of sediment; Variable depending on weather conditions, hydrodynamics, size of the vessel and the experience of the operator affect the quality of the samples and grab failures (grab bouncing, drift, pressure waves).	Quantitative	Collection of mobile epibenthic species limited. Insufficient penetration depth - can miss deep burrowing species.	
Corers	Endobenthos	See grabs. Longer handling time compared to grabs, unsuitable under rough weather conditions (more than 5 Beaufort).	Quantitative	See grabs. Undisturbed sediment cores.	Additional observation and measure devices can be added to the frame, cores used for boxcosm-experiments, benthic chamber measurements.
Trawls and sledges	Epibenthos, hyperbenthos, nekton	Variable depending on weather conditions, hydrodynamics, size of the vessel, the experience of the operator, and failures (drift, pressure waves).	Semi-quantitative; Accuracy depending on the mesh size, tow length should be recorded with depth sensor. The shorter the tow length, the more accurate the information on the spatial structure of the population.	Gear may skip over the seabed, reducing the area sampled. Nets may clog, reducing the sample efficiency. Catchability may vary depending on various factors, which often makes comparisons of relative abundance difficult.	Trawl performance should be checked by electronic monitoring devices (e.g. video).
Dredges	Endobenthos, epibenthos	Varying penetration depth for different sediment types. See trawls and sledges.	Semi-quantitative	Catchability may vary depending on various factors, which often makes comparisons of relative abundance difficult.	
Nets	Nekton, plankton	Variable depending on the specifications of the gear (esp. mesh size), weather conditions, tow speed, hydrodynamics, size of the vessel, and the experience of the operator.	Semi-quantitative. Accuracy depending on the mesh size	Nets may clog, reducing the sample efficiency.	
Visual (diving)	Epibenthos, nekton	Non-destructive. Appropriate for protected species/habitats. Appropriate for all kinds of substrates/habitats (rocky and coral reefs, sandy/muddy bottoms, seagrasses, etc). No permanent record.	Quantitative	Imperfect detectability will lead to underestimation of abundance.	When there is no assurance of perfect detectability, distance sampling methods may be preferable.
Photocameras	Epibenthos, nekton, plankton	Non-destructive. (Specific) recognizable taxa. Images in 2D or 3D.	Quantitative (when scaled). Image resolution and visibility limiting.	Imperfect detectability will lead to underestimation of abundance. Difficulties in taxa identification may lead to underestimation of abundance and diversity measures.	Illumination-dependent (except in shallow and clear waters) "4D" (time advantage).
Drop-down video cameras a) ROV/submersible	Epibenthos, nekton, plankton	Non-destructive. Limited use in tidal currents or windy conditions. Active control of position in small scale. Transect observation.	Quantitative (when scaled). Limiting accuracy: image resolution and visibility.	Imperfect detectability will lead to underestimation of abundance. Difficulties in taxa identification may lead to underestimation of abundance and diversity measures. Response of mobile species to ROVs/submersibles may be a source of substantial bias.	Speed, illumination, turbidity-dependent.
Drop-down video cameras b) Lander	Epibenthos, nekton, plankton	Non-destructive. Continuous monitoring possible.	Quantitative (when scaled). Limiting accuracy: image resolution and visibility.	Imperfect detectability will lead to underestimation of abundance. Difficulties in taxa identification may lead to underestimation of abundance and diversity measures.	Illumination, turbidity-dependent "4D" (time advantage).
Towed video cameras	Epibenthos, nekton, plankton	Non-destructive. Limited flexibility for species recognition. Inertia in direction changes.	Towing speed influences image quality and positional accuracy.	Imperfect detectability will lead to underestimation of abundance. Difficulties in taxa identification may lead to underestimation of abundance and diversity measures.	Speed, illumination, turbidity depended. Attaching weights to the camera frame might be required to maintain position.
Hydro-acoustics	Reefbuilding epibenthos, nekton	Non-destructive. Cost-effective method over large areas.	Qualitative, low resolution. Only specific ecosystem components.		Ground-truthing needed.

Fig. S1. The box corer (Plot sampling) is used for endobenthos, the major advantage is to collect sediment blocks with negligible disturbance. Recovered onboard, the box can be detached from the frame for subsampling and further analysis. Photo: Senckenberg, Sandra Vöge.

Fig. S2. The Van Veen grab (Plot Sampling) is used for endobenthos, it is more suitable under rough weather conditions than box corers. Photo: Senckenberg, Sven Traenkner.

Fig. S3. Agassiz trawl (Plot Sampling). This demersal trawl is used to catch epibenthos. In advantage to other trawls the Agassiz trawl works on either side when landing on the seafloor, which improves catchability. Photo: Hartmut Arndt.

Fig. S4. The epibenthos sledge (EBS) (Plot Sampling) is a metal frame with one or several nets; the sledge is equipped with an automatic opening and closing device. Photo: Senckenberg, Inga Mohrbeck.

Fig. S5. Dredge (Plot Sampling). Dredges are used to catch endo- and epibenthos. Depending on the surface, dredges can dig into the sediment or scrape organisms off hard surfaces. Photo: Senckenberg, Sven Traenkner.

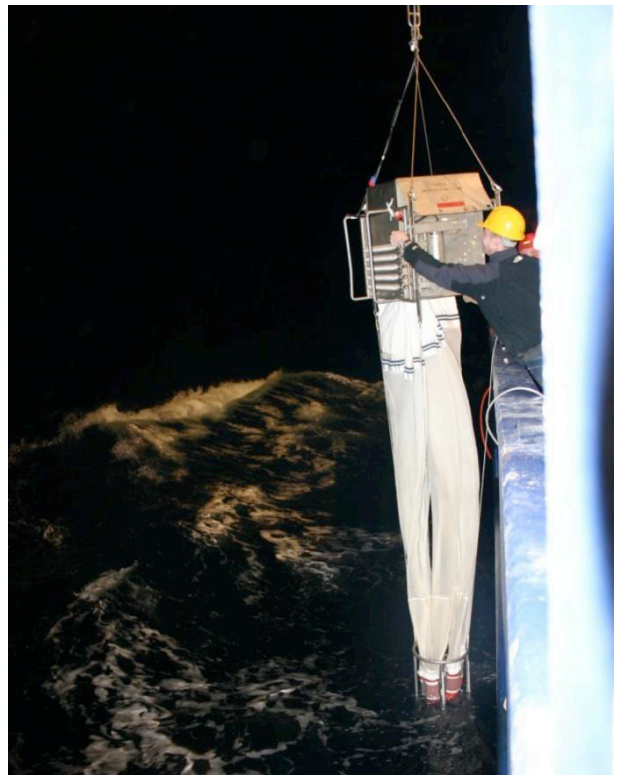

Fig. S6. Plankton net (Plot Sampling). Plankton nets can be operated horizontally and vertically. Here the automatic opening and closing allows vertical sampling at different depths. Photo: Senckenberg, Joachim Scholz.

Fig. S7. Remotely Operated Vehicle (ROV) “Cherokee” (Plot Sampling). This underwater vehicle dives 1000 m deep, is equipped with cameras and can collect samples. Photo: MARUM, Universität Bremen.

Fig. S8. Shipboard Strip Transects (Plot Sampling): Conducting a visual survey for jellyfish from a passenger ferry (platform of opportunity). Photo: Thomas Doyle.

Fig. S9. Typical high-wing twin propeller aircraft used in aerial surveys for strip transects (Plot Sampling) or line transects (Distance Sampling) of marine mammals, seabirds, large fish, jellyfish etc. Photo: Tom Doyle

Fig. S10. Underwater quadrat sampling (Plot Sampling). The square frame may be subdivided in smaller squares to facilitate counting (or even to collect separate data for each sub-quadrat and also analyze small-scale variation of counts). Photo: Yiannis Issaris.

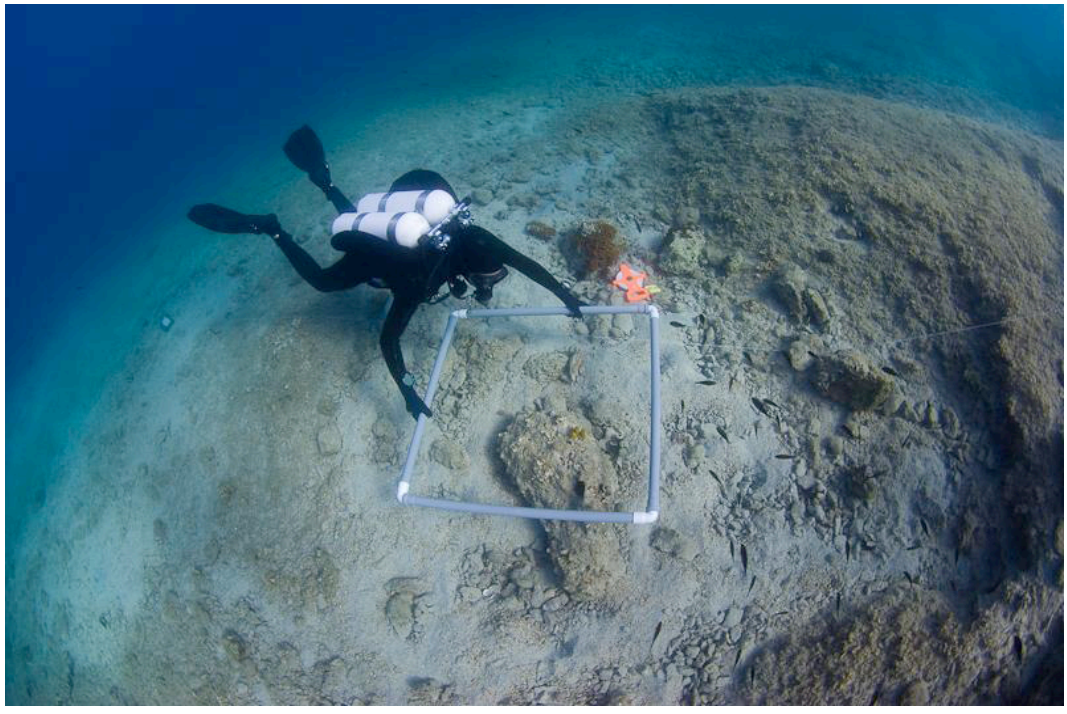

Fig. S11. Underwater quadrat sampling (Plot Sampling). The size of the quadrats depend on the target species and its population density as well as the habitat type. Here a 1m x 1m plastic frame is used to count sponge colonies. Photo: Yiannis Issaris.

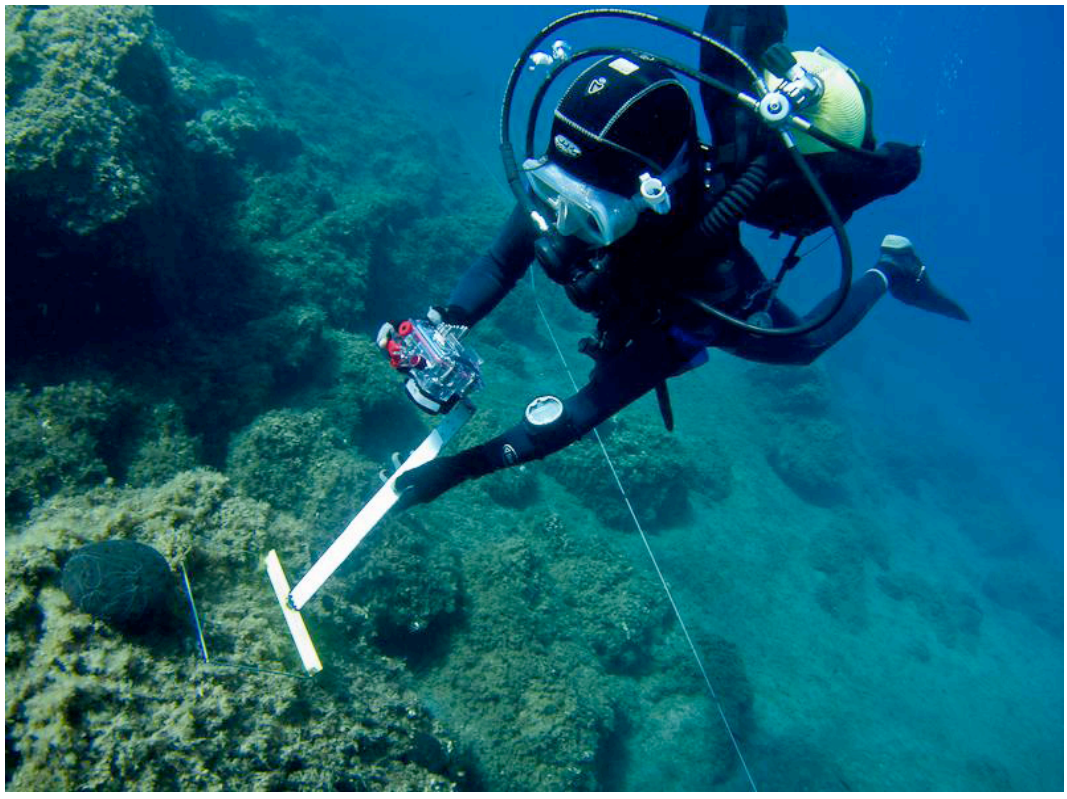

Fig. S12. Underwater photo quadrats (Plot Sampling): For estimations of abundance of small invertebrates or percent cover of sessile species, plot sampling with photo quadrats may be conducted. Instead of counting individuals or percent species cover in situ, as in other plot sampling techniques, photos of quadrats are taken and analyzed later in the lab. Photo: Yiannis Issaris.

Fig. S13. Sampling macrofauna. Scuba sampling with corers (Plot Sampling). Photo: Yiannis Issaris.

Fig. S14. In strip transects (Plot Sampling) or line transects (Distance Sampling) in underwater visual surveys, the simplest and best way to define a transect is by delineating the center-line. Here the diver-researcher deploys a nylon line with a use of a diving reel; an underwater compass is used to position a straight line in the desired direction of the transect. Photo: Yiannis Issaris.

Fig. S15. In strip transects (Plot Sampling) the diver-researcher counts every individual detected within a pre-defined distance from the center-line. Here the diver uses a 2-m plastic rod to easily find out whether a detected individual is within a 4-m wide strip (2 m from each side of the center-line). Photo: Yiannis Issaris.

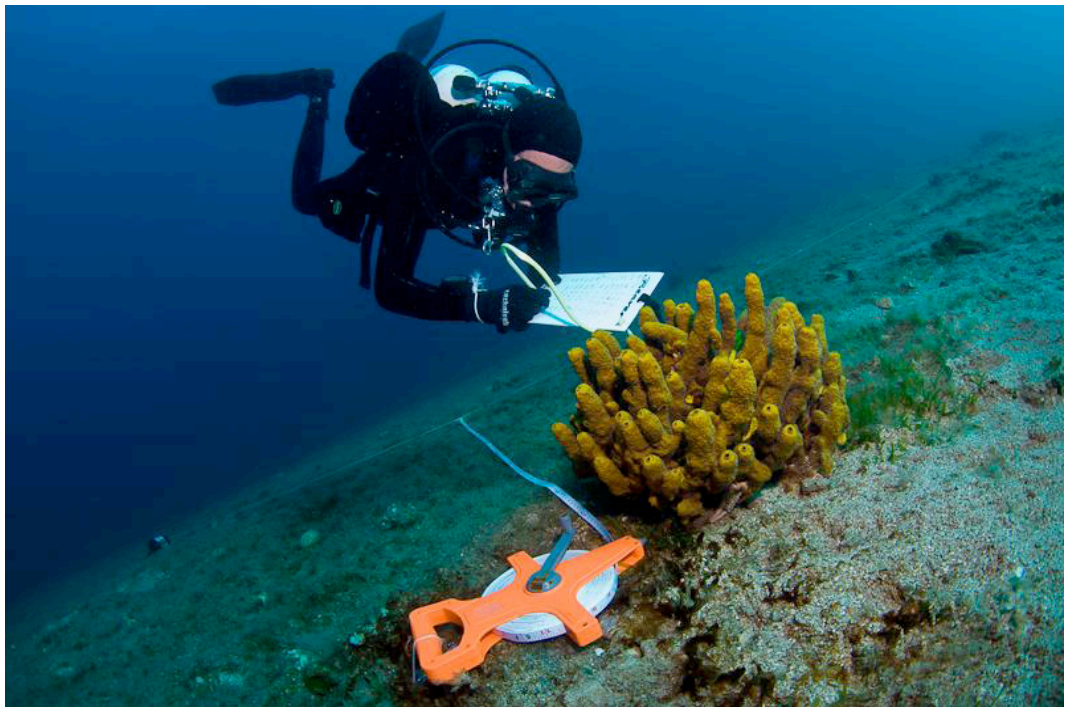

Fig. S16. In line transects (Distance Sampling) the extra effort in relation to strip transects is to measure the perpendicular distance from the line of every individual of the target species. Here a tape measure is used to measure the distance of a sponge colony (*Aplysina aerophoba*) from the center line. Photo: Yiannis Issaris.

Fig. S17. Mark-Recapture: The success of the mark recapture technique depends also on the kind of tag used. Here, a coded T-bar tag is placed on a spiny lobster (*Palinurus elephas*). Photo: Giovanni D'Anna.

Fig. S18. Mark-Recapture: Tagging procedure to put a visible implant elastomer in the fin tissue of a juvenile white seabream (*Diplodus sargus*). Photo: Vincenzo Maximiliano Giacalone

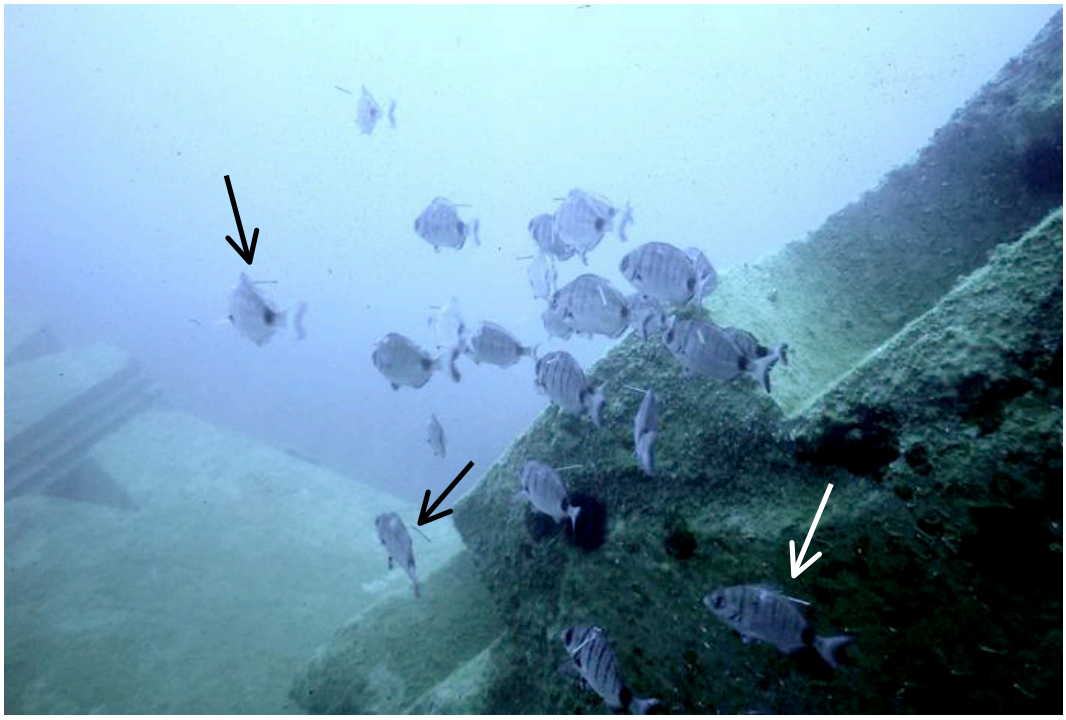

Fig. S19. Mark-Recapture: T-Bar tags (examples indicated by arrows) applied to white seabreams (*Diplodus sargus*) released in an artificial reef area to estimate abundance and movement of tagged specimens. Photo: Giovanni D'Anna.

Fig. S20. Mark-Recapture: Underwater picture of white seabreams (*Diplodus sargus*) tagged with visible implant elastomer (reddish spots). Photo: Vincenzo Maximiliano Giacalone.

Fig. S21. Nest counts are the most universally used technique to monitor marine turtle populations. This photo is from the National Marine Park of Zakynthos (Greece), which encloses the most important loggerhead sea turtle *Caretta caretta* nesting rookery in the Mediterranean. During each breeding season, nests are spotted, counted, mapped, and protected from beachgoers with these special wooden cages. Photo: Yiannis Issaris.

Fig. S22. Colony counts is a method applied to monitor seals that aggregate at terrestrial haul-out sites. (Top left) Image of harbour seals and grey seals hauled out on sand-bar in Ireland, acquired by conventional digital photography from aircraft. (Top right) Thermal imager mounted in helicopter for harbour seal surveying. (Bottom) Thermal image of harbour seals on rocky shore; thermal imagery works best on rocky shores, as seals are not easily detected by conventional photography. Photos: Michelle Cronin (top) and SMRU (bottom).

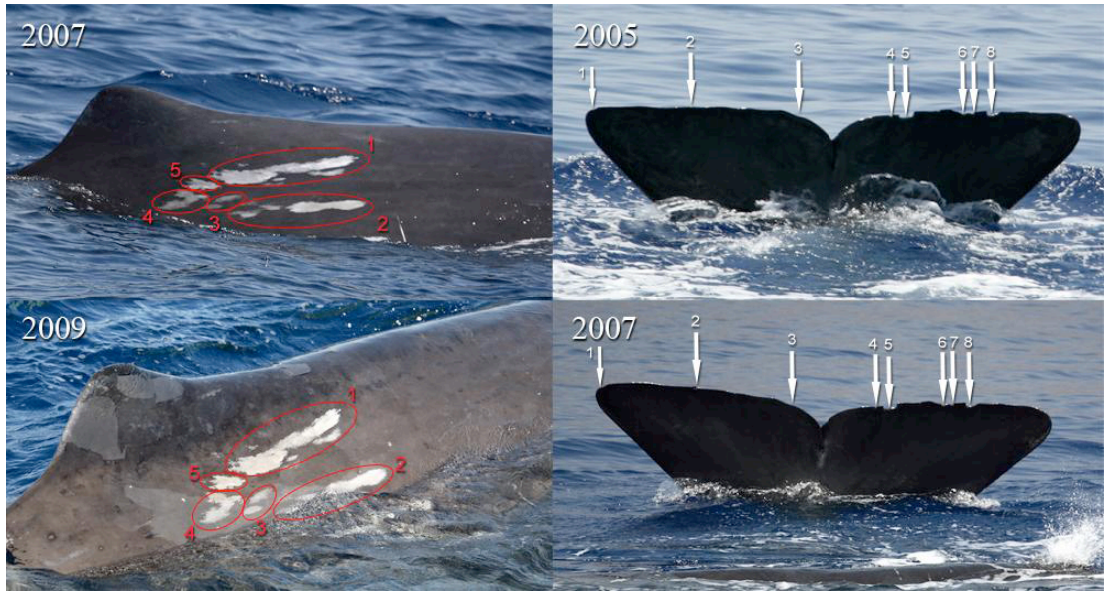

Fig. S23. Mark-recapture based on photo-identification is applied for monitoring cetaceans. Natural markings such as those indicated in the above photographs are used to identify individuals. (Left) Permanent pigmentation in dorsal fin area of a sperm whale, „marked" in 2007 and „recaptured" in 2009. (Right) Nicks, notches and scallops on the trailing edge of the fluke of a sperm whale, „marked" in 2005 and „recaptured" in 2007. Photos: A. Frantzis / Pelagos Cetacean Research Institute.

Fig. S24. Ringing a *Larus michahellis* (yellow-legged gull) fledgling. Mark-recapture techniques are widely applied for monitoring of bird populations. Birds are captured (as chicks before fledging or breeding adults at the nest or with the use of mist-nets placed near the breeding colonies) and ringed, usually with easily read numbered rings. Photo: Roula Trigou/ Hellenic Ornithological Society