

Supplementary Materials for

Mobile robotic platforms for the acoustic tracking of deep-sea demersal fishery resources

I. Masmitja*, J. Navarro, S. Gomariz, J. Aguzzi, B. Kieft, T. O'Reilly, K. Katija, P. J. Bouvet, C. Fannjiang, M. Vigo, P. Puig, A. Alcocer, G. Vallicrosa, N. Palomeras, M. Carreras, J. del Rio, J. B. Company

*Corresponding author. Email: ivan.masmitja@upc.edu

Published 25 November 2020, *Sci. Robot.* **5**, eabc3701 (2020)
DOI: 10.1126/scirobotics.abc3701

The PDF file includes:

Fig. S1. Algorithms' performance versus receivers' position.
Fig. S2. TDOA algorithms performance over the time.
Fig. S3. Reception ratio.
Fig. S4. Fieldwork methods evaluation at the OBSEA platform.
Table S1. Algorithms' performance during the Norway lobster experiment.
Legends for movies S1 to S4

Other Supplementary Material for this manuscript includes the following:

(available at robotics.sciencemag.org/cgi/content/full/5/48/eabc3701/DC1)

Movie S1 (.mp4 format). Simulation of target tracking using TDOA.
Movie S2 (.mp4 format). Simulation of target tracking using AOTT.
Movie S3 (.mp4 format). Norway lobster movements.
Movie S4 (.mp4 format). Seabed images.

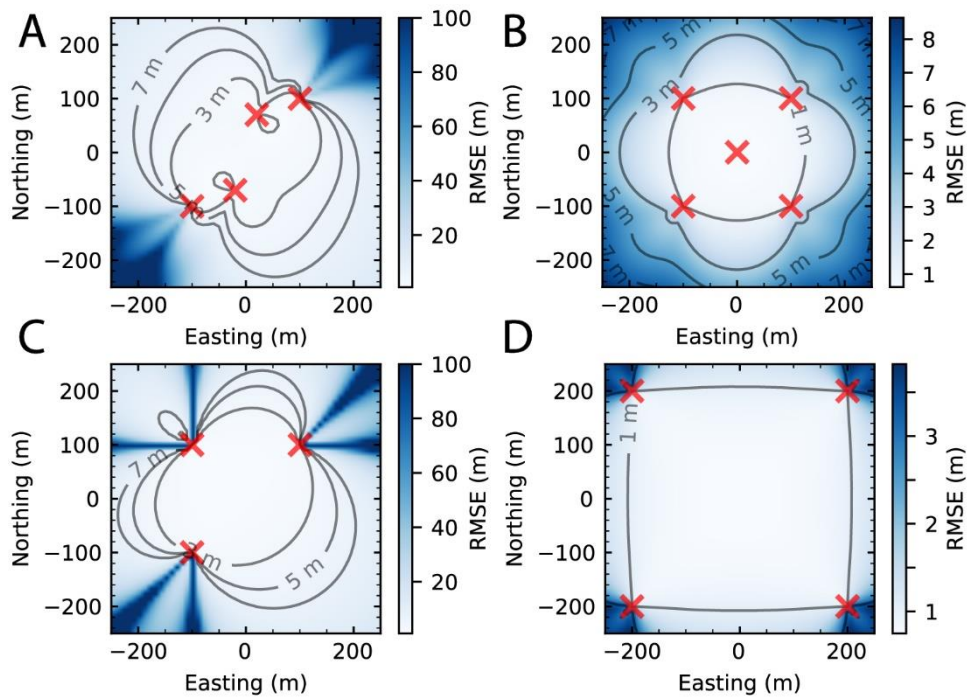


Fig. S1. Algorithms' performance versus receivers' position. The CRB for TDOA target estimation using different receivers' configuration (red crosses). (A) four receivers using a non-square shape. Using five receivers the error is reduced (B), whereas using only three receivers the error clearly augments (C). If the separation between receivers is augmented (i.e. we have a greater baseline distance), so does the accuracy (D).

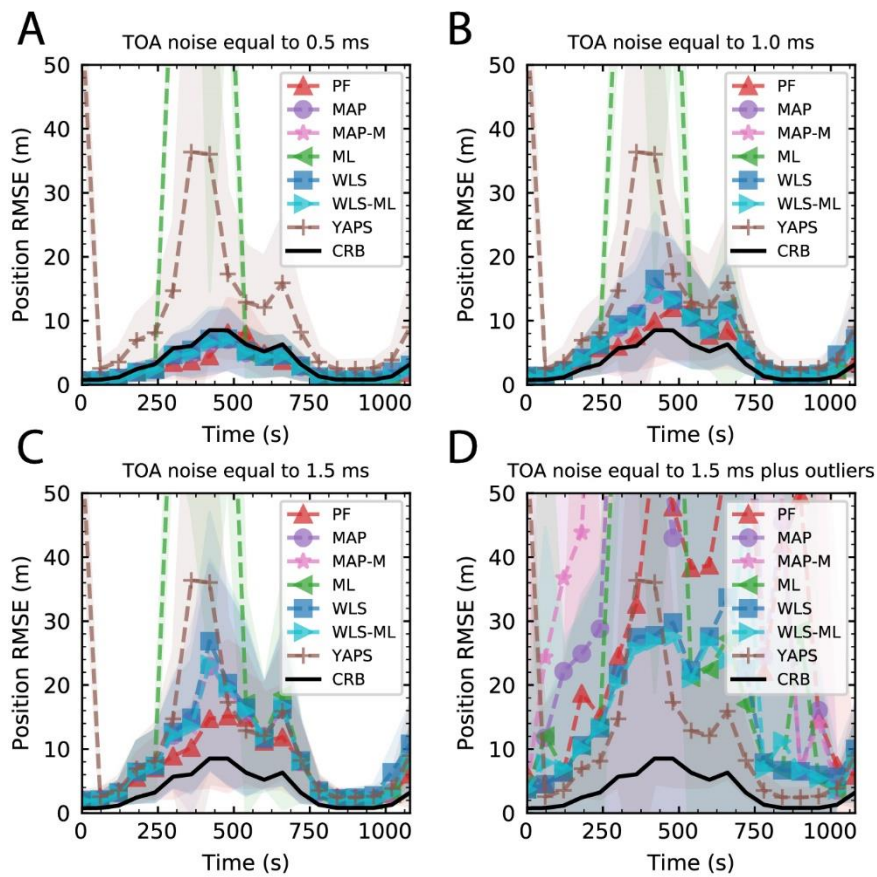


Fig. S2. TDOA algorithms performance over the time. The RMSE evolution over the time for different algorithms and compared with CRB. (A) using a Gaussian noise of 0.5 ms added at each TOA measurement, (B) using a Gaussian noise of 1.0 ms, (C) using a Gaussian noise of 1.5 ms, and (D) using a Gaussian noise of 1.5 ms plus a random outlier (i.e. multiplying by 4 the TOA measured).

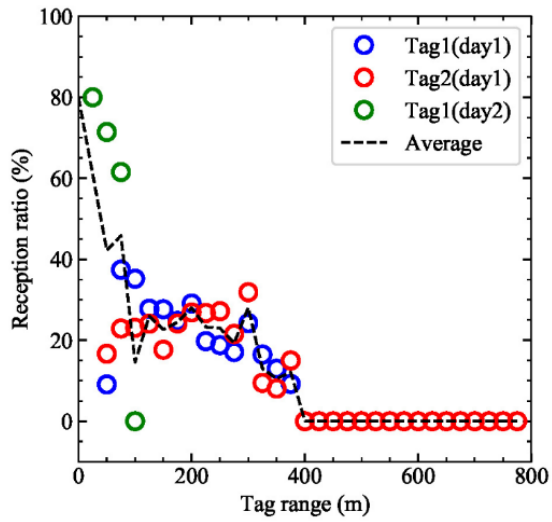


Fig. S3. Reception ratio. Reception ratio versus distance between devices. Results obtained during field trials in Monterey Bay, California, between a Wave Glider and an acoustic tag (V7P-69 kHz).

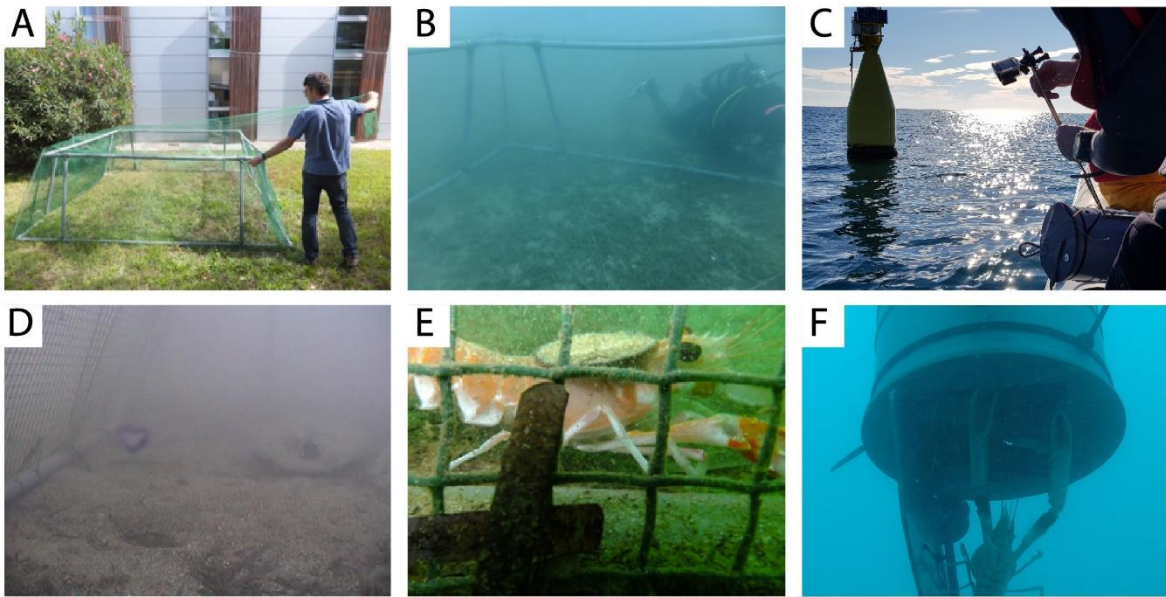


Fig. S4. Fieldwork methods evaluation at the OBSEA platform. The OBSEA (www.obsea.es) is an underwater cabled observatory located at 20 m depth in the “Coll Mira el Peix” Marine Protected (EU Natura 2000 network) area. **(A)** The cage was built at the Universitat Politècnica de Catalunya facilities. **(B)** the cage installation by divers at the cabled observatory, in front of the video camera. **(C)** Testing the automatic release canister to release the Norway lobsters. **(D)** Different artificial burrows, made by PVC pipes buried in concrete, were also installed inside the cage. **(E)** a Norway lobster inside the cage (with an attached visual tag mimicking the Vemco emitter and also used to facilitate the remote visual inspection *via* the camera). And **(F)** one of the animals being released by the canister.

Table S1. Algorithms' performance during the Norway lobster experiment. Error and standard deviation of each Vemco acoustic receiver (BS) and the lobster canister (denoted as BS(C)), and their synchronization tag associated, using different TDOA algorithms.

Algorithms	BS(A)		BS(B)		BS(C)		BS(D)		BS(E)	
	error (m)	SD (m)	error (m)	SD (m)	error (m)	SD (m)	error (m)	SD (m)	error (m)	SD (m)
PF	3.20	0.46	3.85	0.20	0.48	0.29	5.36	0.17	10.28	0.16
MAP-M	0.06	0.43	0.06	0.47	0.02	0.25	-	-	0.15	0.40
ML	0.04	0.75	0.01	0.41	0.02	0.25	0.07	0.52	0.04	0.56
WLS	0.03	0.25	0.12	1.22	0.08	0.28	7.07	2.52	9.02	4.67
WLS-ML	0.03	0.27	0.09	0.92	0.02	0.25	0.15	0.91	0.02	0.74

Movie S1. Simulation of target tracking using TDOA. One of the simulations conducted to observe the performance of different algorithms for target tracking using TDOA signals.

Movie S2. Simulation of target tracking using AOTT. One of the simulations conducted to observe the performance of tagged target tracking using the AOTT algorithm.

Movie S3. Norway lobster movements. Trajectory conducted by the 33 Norway lobsters tagged during the RESNEP campaign, first three days.

Movie S4. Seabed images. Images of the seabed obtained inside the area of the Norway lobster experiment by the ROV.