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Passive Acoustic Monitoring of fish with Distributed Acoustic Sensing^{a)}

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1 Underwater soundscapes are critical indicators of marine ecosystem health, but tra-
2 ditional passive acoustic monitoring (PAM) with hydrophones is spatially limited
3 and logistically challenging for long-term observations. This study investigates the
4 potential of distributed acoustic sensing (DAS) to overcome these limitations. A
5 field trial was conducted using a bespoke fiber-optic cable deployed off the coast of
6 Monaco, focusing on three sound-producing Mediterranean species: *Ophidion rochei*,
7 *Sciaena umbra*, and *Epinephelus marginatus*, all known for their distinct acoustic sig-
8 natures during reproductive activity. DAS recordings reveal species-specific patterns
9 consistent with documented behaviors, and validated by simultaneous hydrophone
10 recording. Thanks to its high sensor density, DAS enables the isolation and local-
11 ization of individual sounds over tens of meters. The results demonstrate that DAS
12 can reliably detect and locate fish sounds under real-world conditions, while also as-
13 sessing ambient noise levels. If the DAS setup of this experiment may not match the
14 performance of conventional hydrophones at frequencies above 1kHz, the many other
15 advantages of the approach point to a high potential for marine conservation in the
16 context of climate change and biodiversity loss.

a) Preliminary results of this work were presented during the talk "Unlocking the Potential of Distributed Acoustic Sensing for Ocean Monitoring and Management", One Science Ocean Congress, Nice, France, June 2025.

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17 I. THE BIOPHONY KNOWLEDGE GAP AND THE LIMITATIONS OF TRA- 18 DITIONAL MONITORING

19 The oceans cover more than 70% of the Earth's surface and play a crucial role in the
20 planet's health by absorbing carbon dioxide (Sabine *et al.*, 2004), producing approximately
21 half of the oxygen (Grégoire *et al.*, 2023), and hosting vast ecosystems. However, they
22 are facing increasing threats from human activities and climate change. Global pressures,
23 including temperature rise, eutrophication, coastal urbanization, invasive species, and over-
24 fishing, modify ecosystem structure worldwide (Boudouresque *et al.*, 2024; Coll *et al.*, 2012,
25 2010; Klaoudatos *et al.*, 2024; Lejeusne *et al.*, 2010; Tsirintanis *et al.*, 2022). Anthropogenic
26 underwater noise made by dredging, seismic surveys, and naval activities all contribute to
27 acoustic habitat degradation (Carmezim *et al.*, 2022; Di Franco *et al.*, 2020).

28 These worldwide trends are most evident in highly populated, semi-enclosed seas, such as
29 the Mediterranean, where all these factors have led to an alarming proportion of threatened
30 marine species (Klaoudatos *et al.*, 2024). At least 20% of the fish taxa are now under threat
31 of extinction in the area, combined with a significant lack of data according to the European
32 Red List of Fishes (Nieto *et al.*, 2015).

33 Sound is a fundamental communication channel in aquatic environments (Radford *et al.*,
34 2014). Unlike light or chemical signals, acoustic signals can travel more effectively over
35 long distances, making them indispensable to many fish species for essential activities such
36 as reproduction, or territorial defense (Lobel *et al.*, 2010; Rountree *et al.*, 2006). A noisy
37 environment reduces effective signal detection range by several hundred meters (Codarin

38 *et al.*, 2009). Limiting that acoustic disturbance is increasingly recognized as an essential
39 measure for preserving marine biodiversity (European Commission, 2017; Nedelec *et al.*,
40 2022).

41 The ensemble of sounds produced by living organisms, or “biophony”, is an indicator of
42 biodiversity and ecosystem health (La Manna *et al.*, 2021; Staaterman *et al.*, 2017). Early
43 comprehensive overviews of fish sound production and acoustic perception, such as Tavalga
44 (1971) and Hawkins (1986), emphasized the diversity of mechanisms and ecological roles of
45 acoustic communication in marine fishes. Since then, PAM has been employed to detect and
46 track temporally sound-producing fish and marine mammals at relatively low cost (Desiderà
47 *et al.*, 2019; Gannon, 2008; Lindseth and Lobel, 2018; Rountree *et al.*, 2006; Van Parijs *et al.*,
48 2009). It has been effectively used for detecting spawning sites, determining nocturnal vocal
49 behavior, and assessing behavioral response to noise pollution (Di Iorio *et al.*, 2021; Picciulin
50 *et al.*, 2013a).

51 Fish produce a wide range of sounds, including frequency-modulated calls and structured
52 pulse sequences (La Manna *et al.*, 2021). These signals have obvious ecological functions, but
53 many of them remain poorly described at the species level. To help fill the gap, a global ef-
54 fort was undertaken to catalog underwater biological sounds (Parsons *et al.*, 2022). This has
55 resulted in the creation of *FishSounds.net*, a platform that groups recordings and references
56 for more than a thousand species. While this website is a valuable resource for scientists
57 working on fish bioacoustics (Looby *et al.*, 2023), the vast majority of fish biophony remains
58 undocumented: 96% according to Looby *et al.* (2022). This significant knowledge gap is
59 partly due to some limitations of traditional Passive Acoustic Monitoring (PAM). For in-

60 stance, conventional hydrophone deployments cover limited spatial scales, requiring manual
61 installation and retrieval, and multi-sensor networks are costly and logistically cumbersome.
62 Consequently, it is impractical to monitor large systems and their dynamic (Van Horn *et al.*,
63 2025). Distributed Acoustic Sensing (DAS) is a photonic technology with several key advan-
64 tages that could potentially overcome these constraints (Cavanaugh *et al.*, 2024). It enables
65 any fiber-optic cable to function as a dense array of virtual acoustic sensors by detecting
66 phase changes in Rayleigh backscattered laser pulses (ϕ -OTDR) (Hartog, 2017; Sladen *et al.*,
67 2019; Xenaki *et al.*, 2025). With 1.3 million kilometers of submarine cables around the world
68 (TeleGeography, 2025), this passive technology represents a unique potential for the knowl-
69 edge and management of oceans, combining logistic and economic efficiency (Lindsey *et al.*,
70 2019). Effectively, with DAS, each meter of a fiber-optic cable can act as an independent
71 channel, offering unprecedented spatial resolution and a frequency bandwidth from sub-hertz
72 to tens of kilohertz, depending on the cable length.

73 DAS was initially developed in the oil and gas sector, particularly for pipeline monitoring
74 (Tanimola and Hill, 2009). Subsequently, it was applied in both land and ocean geophysics
75 for uses such as seismic detection and monitoring of submarine landslides (Sladen *et al.*,
76 2019). More recently, its application has been extended to oceanography and ecology, in-
77 cluding ship tracking, marine mammal monitoring, and the observation of dynamic processes
78 such as currents and surface waves (Bouffaut *et al.*, 2022; Mata Flores *et al.*, 2023; Meulé
79 *et al.*, 2024; Rivet *et al.*, 2021). The DAS system is even becoming increasingly interesting
80 for capturing and locating a wider range of hydroacoustic signals (Douglass *et al.*, 2023;
81 Rychen *et al.*, 2023).

82 In this work, we report on a field test using DAS for passive acoustic fish monitoring,
83 employing a fiber-optic cable deployed in the Mediterranean Sea off the coast of Monaco. We
84 show that DAS is capable of detecting and distinguishing species-specific signals of known
85 sound-producing fish such as *Ophidion rochei*, *Sciaena umbra*, and *Epinephelus marginatus*,
86 with temporal patterns consistent with previously documented behaviors. We also validate
87 DAS recordings with data from a traditional hydrophone collocated with the cable. Our
88 results demonstrate that the approach also enables the generation of spatio-temporal maps
89 of fish activity, allowing for near-real-time acoustic ecosystem surveillance. DAS surpasses
90 many of the limitations of hydrophone-based PAM, including broad spatial coverage, contin-
91 uous and real-time operation, minimal maintenance, and high spatial resolution. However,
92 the technology is relatively recent and still has some limitations, which will be addressed in
93 the discussion [section IV](#).

94 II. EXPERIMENTAL SETUP TO EVALUATE THE DAS CAPABILITIES

95 A. The advantages provided by the coastal waters of Monaco

96 The coastal waters of Monaco have been extensively studied since the 1990s, with regular
97 biological inventory campaigns conducted in the area ([Cottalorda and Francour, 2007](#)).
98 Every three years, the Department of Environment commissions the "Groupe d'Étude du
99 Mérrou" - "Grouper Study Group", a French association active for more than three decades.
100 They evaluate the population dynamics of dusky groupers (*Epinephelus marginatus*) and
101 brown meagres (*Sciaena umbra*), as well as the effectiveness of local conservation measures.

102 These species have been protected in the Principality since 1993 by sovereign ordinances
103 ([Monaco Government, 2024](#)). In September 2024, a survey was conducted directly below
104 the Oceanographic Institute of Monaco. During this campaign, researchers counted 90 dusky
105 groupers and 59 brown meagres ([Mettey, 2024](#)).

106 As these species are well-known for their distinctive sounds, this site is particularly well-
107 suited to evaluate the performance of the DAS approach: *Sciaena umbra* produces beamed
108 pulse trains at dusk, making choruses in spawning aggregations ([Colla et al., 2018](#); [Picci-
109 ulin et al., 2024, 2013a, 2020](#)), while *Epinephelus marginatus* emits low-frequency booms
110 and growls around sunset during spawning aggregations too ([Bertucci et al., 2015](#); [Di Iorio
111 et al., 2021](#)). We will also consider *Ophidion rochei*, which generates nocturnal calls with
112 stereotyped pulse sequences, using a specialized sonic muscle coupled to the swimming blad-
113 der ([Kéver et al., 2016](#); [Parmentier et al., 2010](#)). Overall, this variety of acoustic fish sounds
114 makes the approach relevant for conservation actions ([Desiderà et al., 2019](#)).

115 B. The deployed Instrumentation

116 The experiment was conducted between May 14 and May 21, 2025. We used an Op-
117 toDAS unit from Alcatel Submarine Networks, connected to the Monaco Oceanographic
118 Institute. It was coupled to a 505 m, 5 mm diameter, tight-buffered fiber-optic cable with
119 four single-mode fibers from the *FS.com* manufacturer. The fibers are protected by a he-
120 lical stainless steel armored tube, a stainless steel wire mesh, a layer of Kevlar yarn, and
121 a TPU outer jacket, all designed to provide robust protection of the fibers. This cable
122 was self-deployed along the rocky coastline under the institute ([Figure 1](#)), with the help of

123 divers. Approximately 400 m of fiber were laid underwater, with the first 250 m embedded
 124 in rocky substrate and the remaining 150 m laid over sand, ending near an artificial wreck.
 125 The cable was regularly labeled with colored tape for easy geo-referencing of the DAS chan-
 126 nels. After deployment, the cable position was refined as accurately as possible using divers'
 127 observations and data from the dive tracks.

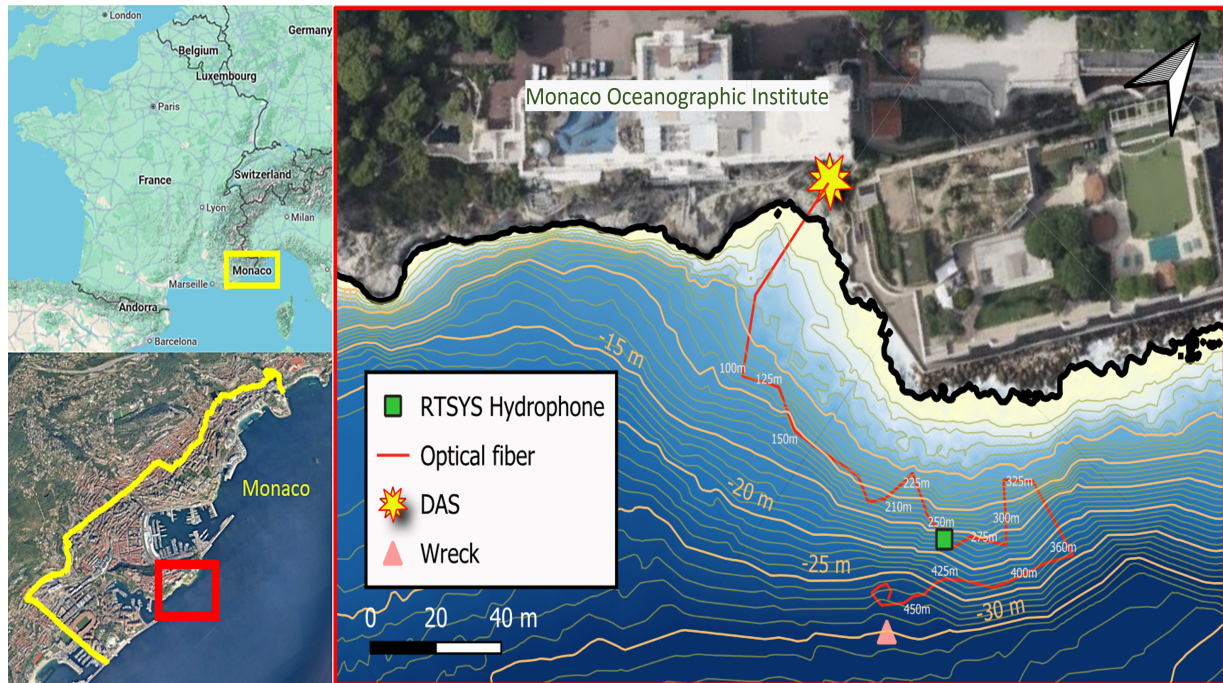


FIG. 1. Map of the Monaco experiment, carried out from May 14 to 21, 2025. The study area is located in Monaco, beneath the Oceanographic Institute. Numbers appearing next to the cable trace represent the distance in meters from the DAS interrogator. Bathymetric data are from the Litto3D PACA 2015 program (SHOM, 2015).

128 DAS recordings were performed at a sampling frequency of 3125 Hz, with a spatial channel
 129 spacing of 1.02 m and a gauge length of 4.08 m. The gauge length corresponds to the
 130 portion of fiber over which backscattered light is integrated to generate each measurement.

131 To compare DAS signals with traditional acoustic data, we installed a professional RTSYS
 132 recorder equipped with an HTI-96-MIN hydrophone (sensitivity: -170 dB re 1 V/ μ Pa;
 133 frequency range: 2 Hz–30 kHz; sampling frequency: 64 kHz). It was placed directly above the
 134 fiber-optic cable (7.4270765° N, 43.7303533° E, depth of 16 m), in a location where groupers
 135 and meagres had been observed during deployment. The nearest DAS channel is number
 136 245, 250 m from the interrogator.

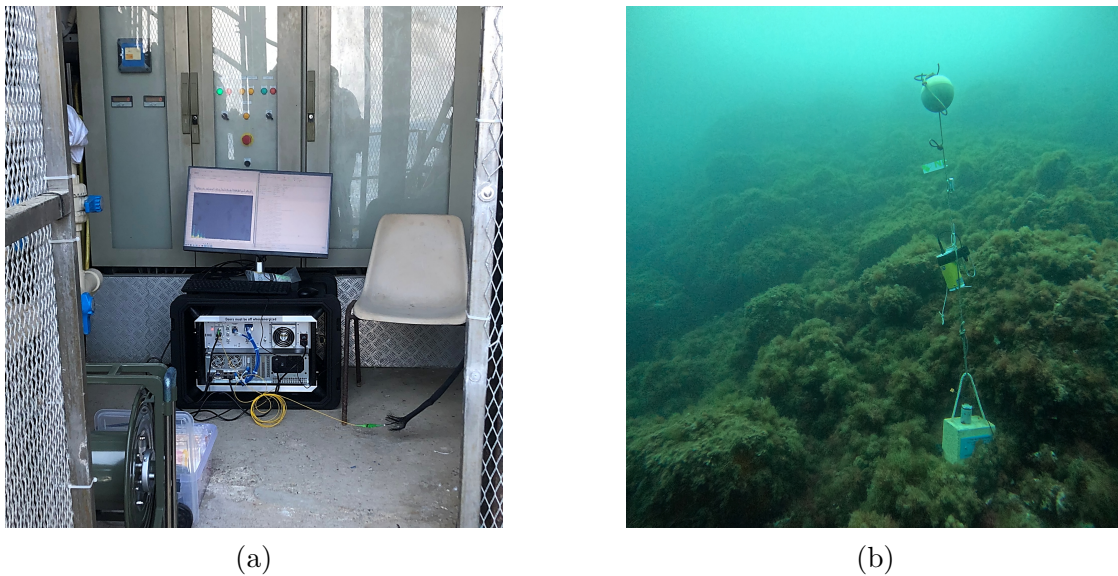


FIG. 2. Illustrations of equipment used: (a) OptoDAS system connected at the Monaco Oceanographic Institute; (b) RTSYS recorder with hydrophone and mooring near the cable.

137 C. Data processing

138 DAS data are extremely large, as the optical fiber effectively provides hundreds of virtual
 139 sensors that record continuously. To efficiently import and process this high-volume dataset
 140 in Python, we used the Xdas library (Trabattoni *et al.*, 2025). The data is then converted to

141 WAV files by normalizing the signal channel by channel and exporting it as 16-bit PCM audio
142 using the `scipy.io.wavfile` module. To visualize and annotate spectrograms from DAS and
143 hydrophones data, we used RavenPro 1.6.5 software ([Cornell Lab of Ornithology, 2024](#)). For
144 spectrograms, we chose a 256-point FFT for DAS data and a 6144-point FFT for hydrophone
145 data, with a Hann window and 50% overlap.

146 III. RESULTS

147 A. Raw observation of fish signals with DAS

148 Several fish calls were successfully detected with the DAS. The sound files for DAS spec-
149 trograms are included as supplementary materials. Among these signals, we identified calls
150 from *Epinephelus marginatus*, *Sciaena umbra*, and *Ophidion rochei* ([Figure 3](#)). In addition,
151 we consistently observed a strong recurring signal along the section of cable near the ar-
152 tificial wreck, corresponding to the “long tonal call” (LT Call) described in the literature
153 ([Desiderà et al., 2019](#); [La Manna et al., 2021](#)). No fish species has yet been associated with
154 this sound.

155 The signals recorded are consistent with those reported in the literature: *S. umbra* pro-
156 duce a repetitive sound in the form of a train of 4 to 7 pulses lasting on average 0.5 s. The
157 dominant frequency is between 200 and 400 Hz, with most of the acoustic energy below 2 kHz
158 ([Picciulin et al., 2013a,b, 2020](#)). *E. marginatus* emits sound with a fundamental frequency
159 under 100 Hz with harmonics. These growls have an average duration of 100 to 400 ms
160 ([Bertucci et al., 2015](#)). *O. rochei* makes sounds of 1 to 5 seconds in duration, consisting of

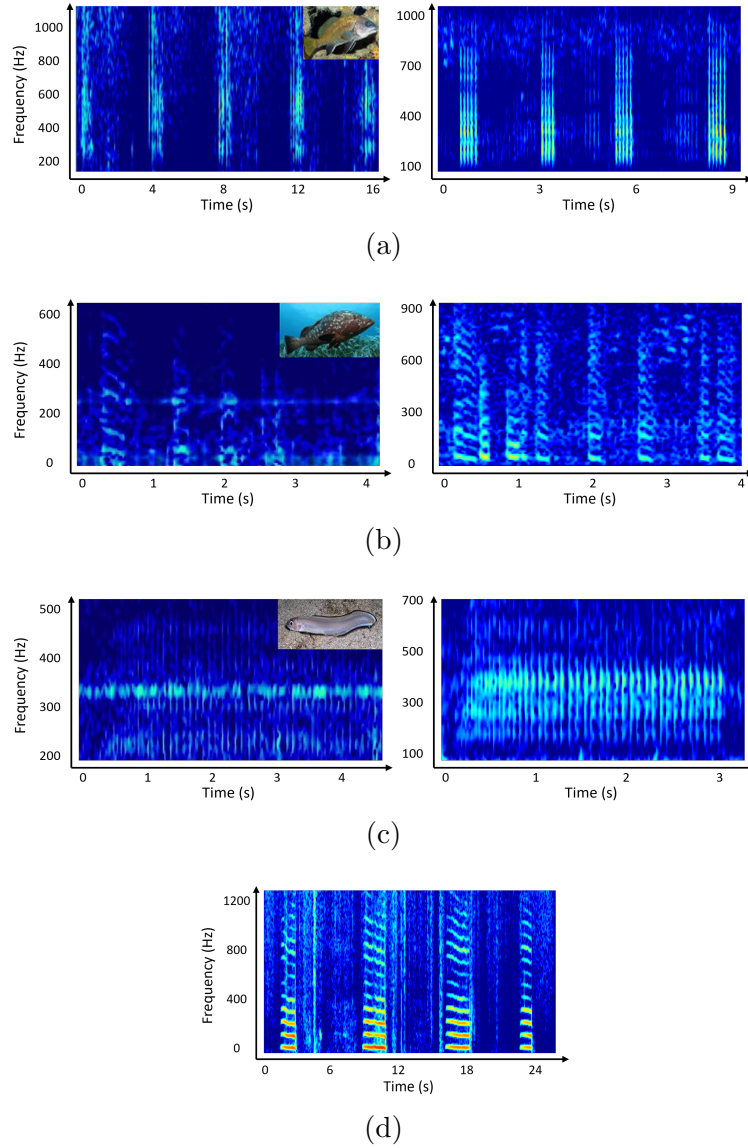


FIG. 3. Spectrogram comparison between DAS-detected signals (left) and signals documented in the literature when possible (right): (a) Regular pulse series by *Sciaena umbra* (SU); (b) Low-frequency downsweeps by *Epinephelus marginatus* (EM); (c) Pulse series with alternating pulse period by *Ophidion rochei* (OR); (d) Long Tonal Calls by unknown fish (LT). The characteristics of signals, such as peak frequency, mean duration, and signal-to-noise ratio (SNR), are listed in [Table I](#).

161 tens of pulses, with two alternating inter-pulse intervals. The acoustic energy is distributed
 162 chiefly between 200 and 400 Hz (Parmentier *et al.*, 2010). However, the long tonal call is
 163 rarely mentioned in the literature. We only know that it is a sound with little frequency
 164 modulation lasting about a second or more (Desiderà *et al.*, 2019; La Manna *et al.*, 2021).

TABLE I. Characteristics of fish signals in Figure 3 for DAS and literature signals (when found).

Fish	Origin	Peak Freq.[Hz]	Mean Duration[s]	SNR
SU	DAS	330 ± 17	0.5 ± 0.1	15 ± 3
	Literature ^a	287 ± 3	0.53 ± 0.05	27 ± 3
EM	DAS	68 ± 2	0.25 ± 0.14	19 ± 3
	Literature ^a	81 ± 12	0.2 ± 0.1	15 ± 4
OR	DAS	230	4.3	15
	Literature ^b	375	2.9	16
LT	DAS	68 ± 1	1.7 ± 0.5	22 ± 2

^a Private communication

^b (Picciulin *et al.*, 2019)

165 B. Spatio-temporal distribution of fish signals along the fiber-optic cable

166 The density of DAS sensors enables precise location through antenna processing (beam-
 167 forming, differences in signal arrival times, etc.), but this type of analysis is beyond the scope

168 of this study. As a first step to estimate the spatial distribution of fish activity, we visually
 169 examine every five channels to determine whether a given fish species is detected and how
 170 the distribution varies in space and time (Figure 4). Long tonal calls are only heard near
 171 the artificial wreck, where the fiber lies on a sandy seabed. *E. marginatus* and *S. umbra*
 172 are commonly found throughout the area, unlike *O. rochei*, which is found in more specific
 173 locations.

174 Another way to examine the data is to compare the time series as a function of distance
 175 to assess the detection range of each signal. Figure 5 represents two types of signals detected
 176 over several tens of channels. This representation thus provides an estimate of the detection
 177 range.

178 C. Comparison between DAS sensors and hydrophone

179 The observed signals are consistent with those reported in the literature. However, it
 180 is still essential to examine how both DAS and hydrophone perceive the same signal. We
 181 compare the two instruments for a *Sciaena umbra* call, as shown in Figure 6. Although
 182 the overall signal shape is similar across both instruments, we observe some differences: the
 183 hydrophone provides a clearer resolution of individual pulses in a train, but the DAS picks
 184 up the signal from *Sciaena umbra* over a wider frequency range, down to 200 Hz and up to
 185 800 Hz.

186 More generally, regarding daily noise variations, the octave-band analysis Figure 7 reveals
 187 that the strain rate level recorded by DAS (dB re $1\mu\epsilon.s^{-1}$) has a similar shape to the sound
 188 levels measured by the hydrophone (dB re $1\mu Pa$) at lower frequencies (≤ 500 Hz). Both

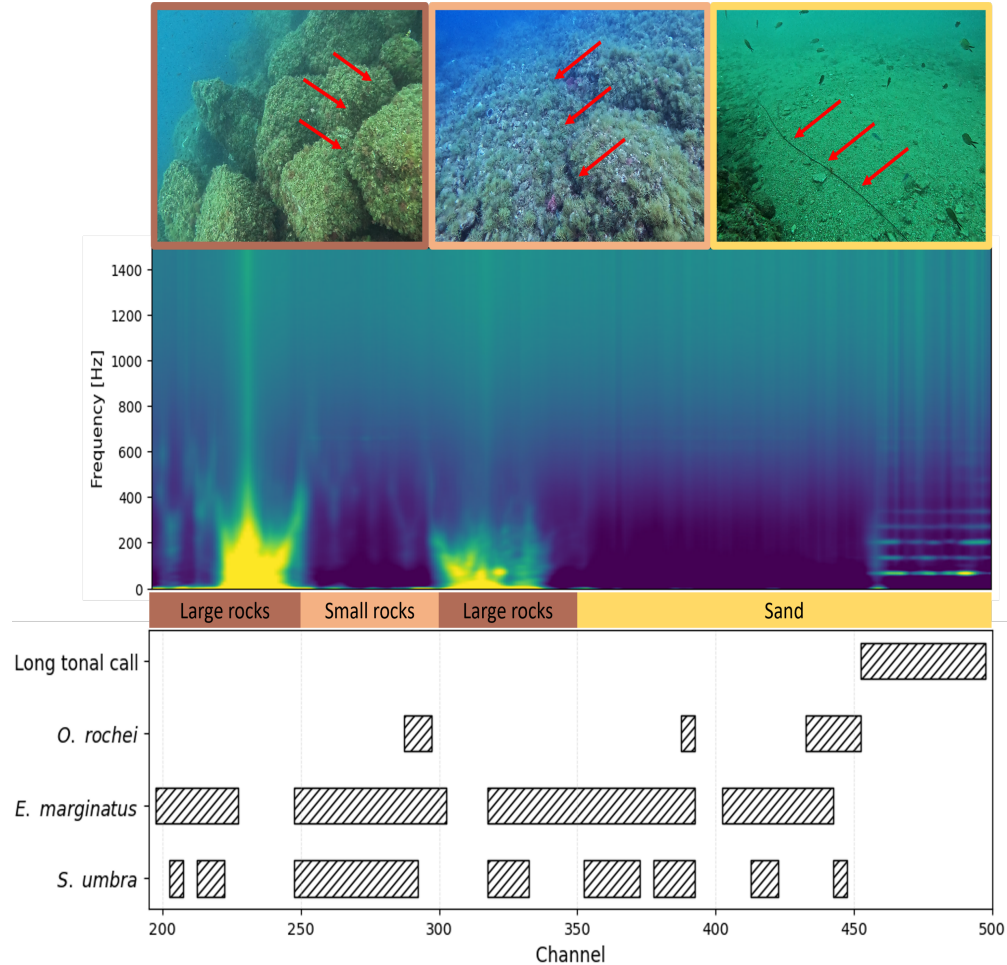


FIG. 4. Images of the different environments encountered (top), Frequency-Distance Diagram (middle), and localization of fish acoustic detections (bottom) along the DAS channels, the night of May 20-21, 2025, 4 pm to 7 am UTC. The red arrows indicate the location of the fiber-optic cable. Around channels 230 and 320, the huge rock blocks suspend most of the cable, which becomes subject to swell-induced vibrations. Simply having smaller rock blocks (middle photo, orange section) significantly reduces the environmental noise. The sandy seabed provides the best recording conditions. These variable seafloor coupling conditions affect the detection capabilities, yet *E. marginatus* and *S. umbra* remain detectable along almost the entire length of the cable.

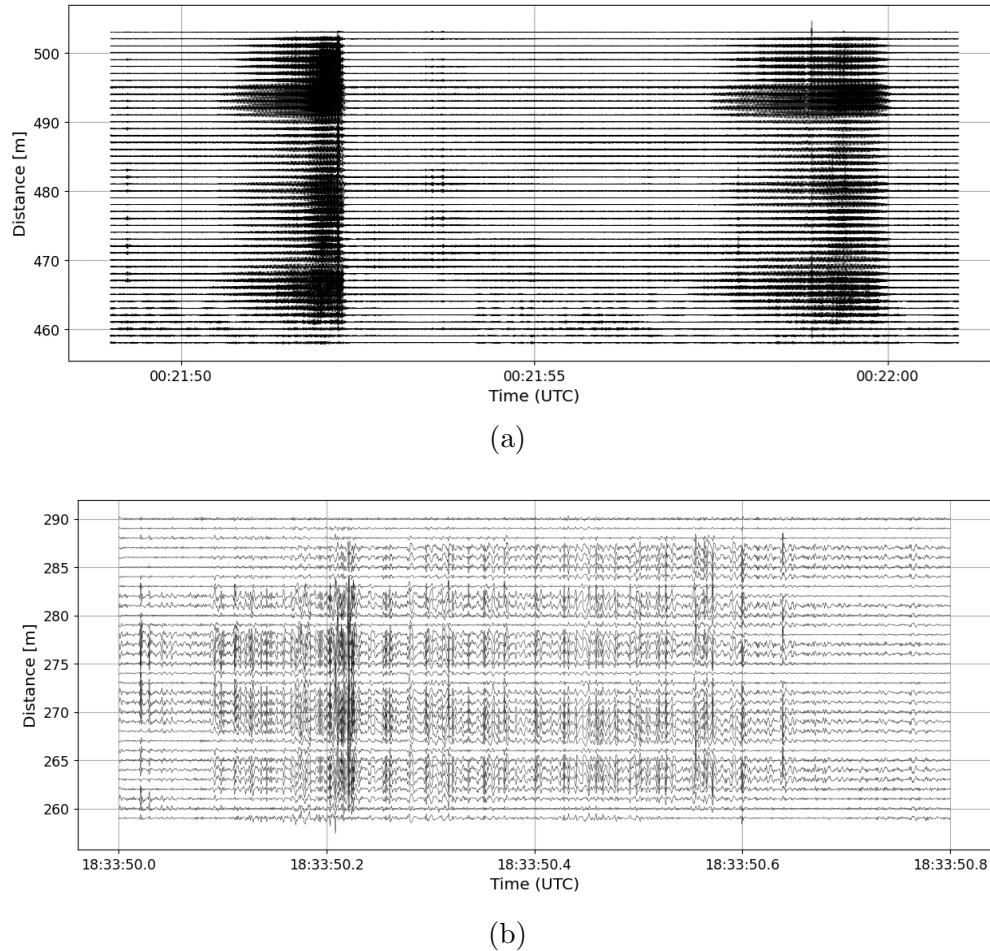


FIG. 5. Multi-channel time series: (a) Two Long Tonal calls arriving at 00:21:52 and 00:21:59 UTC on May 21, 2025, detected over 40 meters; (b) *Sciaena umbra* call at 18:33 UTC on May 20, 2025, detected over 25 meters.

189 instruments particularly reveal an apparent increase in noise during the day, mainly due
 190 to coastal and maritime traffic. It is worth noting that an exceptional noise peak was also
 191 measured on the night of May 19, due to the massive arrival of boats for the beginning of the
 192 Monaco F1 Grand Prix week. Because the interrogator operated at a sampling frequency
 193 of 3125 Hz, it was unable to capture the nocturnal rise in high-frequency noise detected
 194 by the hydrophone, which corresponds to increased biophony. However, the noise at the

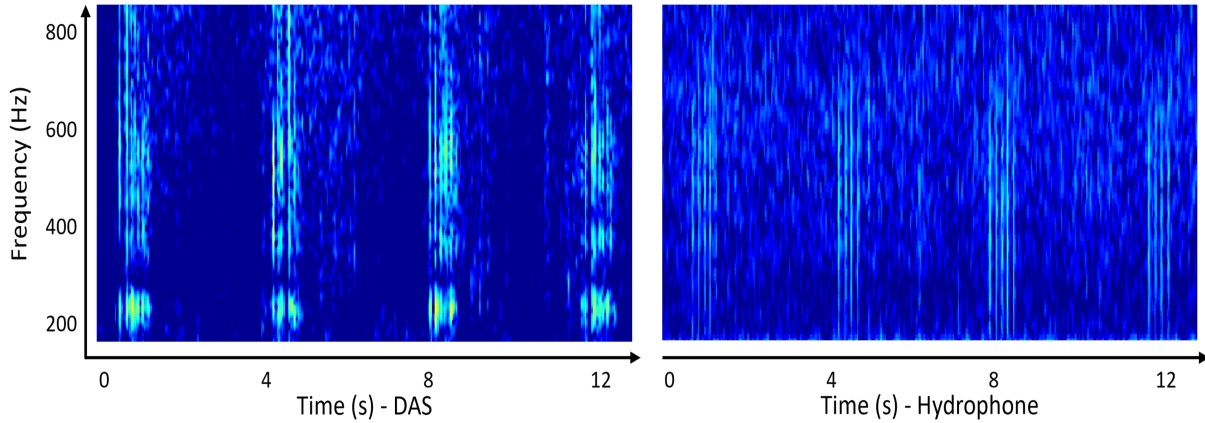


FIG. 6. Comparison between DAS (left) and RTSYS hydrophone (right) for *Sciaena umbra* signals, on May 21 at 4:36 a.m. UTC. Signals from DAS channels 250 to 260 have been stacked to improve the signal-to-noise ratio.

195 1000 Hz octave band is significantly stronger in the DAS data, with the daily variations
 196 barely noticeable. Above the 500 Hz octave band, the average strain-rate level is too high
 197 to observe the nocturnal drop in noise present in the hydrophone data. Because 500 Hz is
 198 high for seismic signals, we suspect this background noise level to be instrumental.

199 The comparison between DAS data and the hydrophone data is inherently limited. While
 200 the hydrophone records only hydroacoustic signals, the fiber-optic cable is also susceptible
 201 to seismic waves propagating through the seafloor. This distinction is particularly relevant
 202 near the coast of Monaco, where anthropogenic activity is high and likely remains significant
 203 at night.

204 The temporal evolution of the transfer function between both DAS and hydrophone
 205 signals, calculated for octave bands from 63 to 1000 Hz, is represented in [Figure 7\(c\)](#). For
 206 each octave band, the transfer function remains relatively stable throughout the week, with

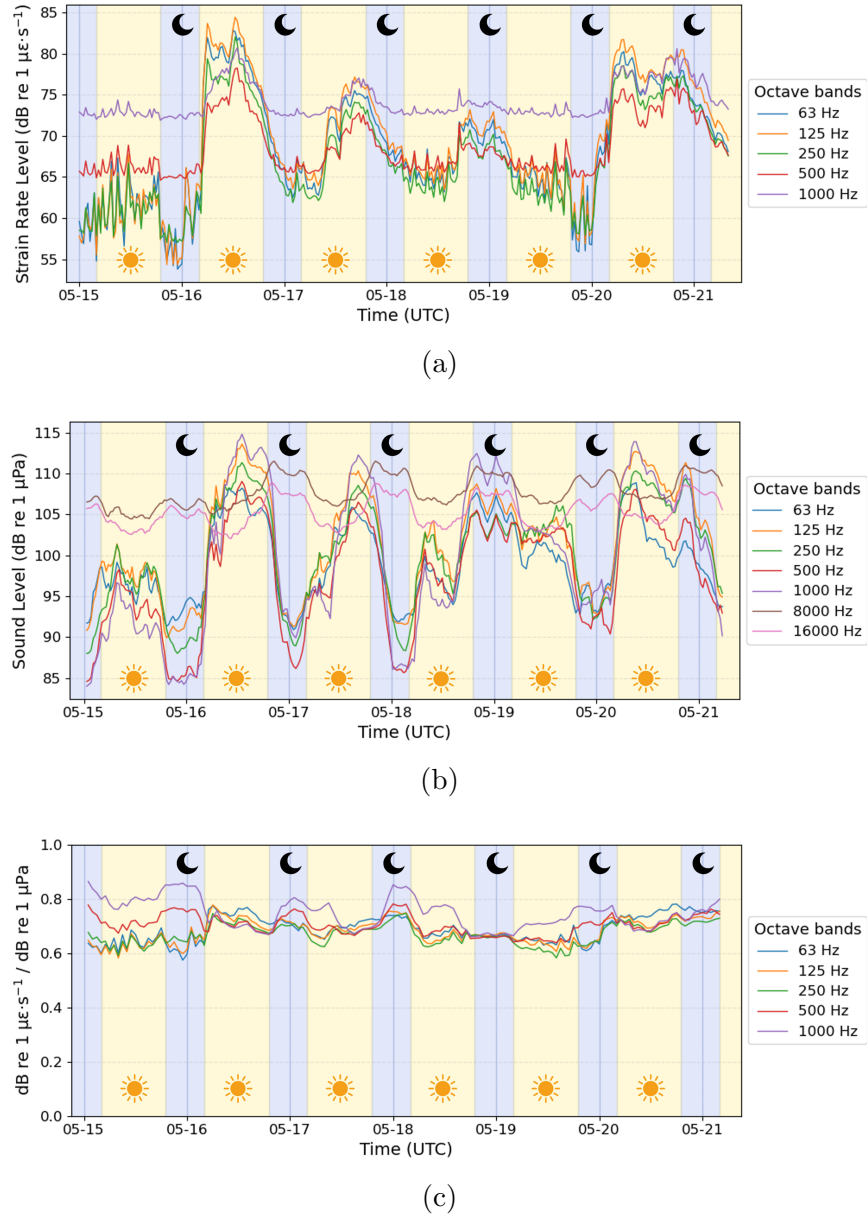


FIG. 7. Octave-band analysis of the acoustic and strain-rate signals over the study period: (a) DAS strain-rate level (dB re $1\mu\epsilon\cdot s^{-1}$); (b) Hydrophone sound pressure level (dB re $1\mu Pa$); (c) Transfer function (DAS/Hydrophone) expressed as the ratio between the two level estimates for each octave band. Shaded backgrounds indicate daytime (yellow) and nighttime (blue) in UTC.

207 variations of approximately 0.1 around the average. The ratio between DAS sensors and
208 the hydrophone varies from 0.68 to 0.75, but the average is remarkably stable below 250
209 Hz (0.685 ± 0.01), and then increases with frequency, reaching 0.71 at 500 Hz and 0.75
210 at 1 kHz. No difference is observed between day and night, suggesting that the evolution
211 of the ratio at high frequencies is more related to the inherent noise of the DAS sensors
212 than to the ambient noise level. These results indicate the relative stability and linearity
213 of the DAS response, as well as the ability to estimate sound pressure levels from DAS
214 data alone (Bouffaut *et al.*, 2025). Optimizing the cable’s physical design is a clear path to
215 improving the response of the DAS sensors. Specifically, we hypothesize that the stainless
216 steel armoring used in the current fiber-optic cable may have attenuated the acoustic signal,
217 thereby limiting the overall sensitivity observed in this study.

218 **IV. DISCUSSION**

219 The results of our experiment support the idea of DAS as a promising approach for moni-
220 toring biophony activity, identifying individuals over extended areas and times with reduced
221 logistical constraints. This work is based on a manually deployed fiber-optic cable, but it
222 clearly demonstrates the potential of DAS in the field of marine bioacoustics. Future work
223 could build on these results by testing existing, more robust submarine telecommunications
224 cables, which already cover the entire oceans. Applying DAS to fish biophony and ecosys-
225 tem soundscapes could enable large-scale continuous ecological monitoring at a much lower
226 cost than traditional observatories. Another significant benefit of using DAS for PAM is its
227 ability to encompass a range of other processes that have a direct impact on the ecosystem.

228 In particular, DAS can precisely quantify ocean surface gravity waves (Meulé *et al.*, 2024),
 229 seafloor currents (Lin *et al.*, 2024; Mata Flores *et al.*, 2023; Song *et al.*, 2024), or temperature
 230 variations down to millikelvins (Pelaez Quiñones *et al.*, 2023). DAS can therefore provide,
 231 at no additional logistical and financial cost, a more comprehensive study of the ecosystems.

232 However, the technology has not been extensively explored at frequencies above a few
 233 hundred Hz due to certain limitations. Fundamentally, one of the main technical constraints
 234 lies in the relationship between the cable length and the temporal resolution. To avoid range
 235 ambiguity, the DAS interrogator must wait for a light pulse to travel to the distal end of
 236 the fiber and for its backscattered signal to return before emitting the next pulse. This
 237 minimum time interval is the round-trip time, $t_{\text{round-trip}}$, which is dependent on the fiber
 238 length, L . This establishes the maximum possible sampling frequency, f_s , of the system.
 239 According to the Nyquist-Shannon sampling theorem, the maximum detectable acoustic
 240 frequency, f_{max} , is half the sampling frequency. Therefore, a longer fiber enforces a lower
 241 maximum pulse repetition frequency (PRF), which in turn reduces the bandwidth of the
 242 acoustic measurement. This relationship is governed by the following:

$$f_{\text{max}} = \frac{f_s}{2} \leq \frac{1}{2 \cdot t_{\text{round-trip}}} = \frac{c}{4Ln} \quad (1)$$

243 Where f_{max} is the maximum detectable acoustic frequency, f_s is the sampling frequency
 244 (i.e., the PRF), L is the total length of the fiber-optic cable, c is the speed of light in
 245 a vacuum ($\sim 3 \times 10^8$ m/s), and n is the effective refractive index of the fiber-optic core
 246 (~ 1.46). If it remains a general limitation of commercial DAS systems, it would be possible
 247 to overcome this limitation through the multiplexing of light pulses, as demonstrated in

248 (Hong *et al.*, 2025). Yet, all recorded bioacoustic signals in the present study are at less
249 than 1 kHz, which means the cable length limit would only be a concern for cables longer
250 than approximately 50 km.

251 Gauge length is also an important parameter. Longer gauge lengths improve the signal-
252 to-noise ratio by averaging the response over a greater number of fiber scatterers. In return,
253 they induce a stronger spatial filtering effect on the recorded signals and should reduce the
254 detection of high-frequency signals (Dean *et al.*, 2017). However, the proper response of DAS
255 at frequencies above a few hundred Hertz doesn't seem to follow the conventional theory
256 (Taweesintananon *et al.*, 2021). Indeed, hydroacoustic signals at up to 2.5kHz, equivalent
257 to a wavelength of about 1.6m ($\frac{1500 \text{ m/s}}{2500 \text{ Hz}} \approx 1.6 \text{ m}$), were recorded during a DAS acquisition
258 with a gauge length of 10m (Rychen *et al.*, 2023). This suggests that the spatial integration
259 of the signal over the gauge length does not limit the response to hydroacoustic signals. The
260 gap in sensitivity with respect to hydrophones could be partially addressed by enhancing the
261 fiber-optic cable's sensitivity to hydroacoustic perturbations. This could be done in several
262 ways which could be implemented in synergy: by improving the ability of DAS interrogators
263 to sense at smaller gauge lengths, by enhancing the mechanical response of the cable's jacket
264 to acoustic perturbations (Celli *et al.*, 2023), wounding the fiber inside the cable to increase
265 the number of channels per meter (He *et al.*, 2025), or optimize scatterers inside the fiber
266 to improve the SNR (Shatalin *et al.*, 2021).

267 The coupling between the cable and the seabed also plays a key role (Igel *et al.*, 2024).
268 As aforementioned, the conversion of hydroacoustic signals into deformation depends on
269 complex coupling mechanisms that remain relatively unexplored (Bouffaut *et al.*, 2025;

270 [Taweessintananon *et al.*, 2021](#)), particularly in heterogeneous environments. Signals are gen-
271 erally better perceived when cables are taut and laid (or even buried) on soft substrates such
272 as sand or mud. The deployment on irregular or rocky bottoms in Monaco resulted in poor
273 coupling in some cable sections, degrading signal clarity and hampering the identification of
274 biological sources ([Figure 4](#)).

275 The volume of data generated by the DAS is a valid concern: the 7-day deployment
276 generated 1.6 terabytes of raw data, with one channel per meter of fiber, resulting in hun-
277 dreds of virtual sensors. We selected a 500-meter cable with a sampling rate of 3125 Hz,
278 providing a suitable compromise between resolution and data volume. Processing and man-
279 ually annotating such datasets would be highly time-consuming. However, this challenge
280 also highlights opportunities for the development of automated approaches, such as machine
281 learning, which are already being tested for marine soundscape monitoring ([Duarte *et al.*,](#)
282 [2024](#); [Dufourq *et al.*, 2022](#)).

283 Noise pollution in these coastal areas is another major limitation. With probably hun-
284 dreds of boats passing through Monaco daily, we encountered persistent high noise levels
285 that overlapped with fish sounds below 1000 Hz. This background noise must have masked
286 the faint or irregular sounds, making detection more difficult.

287 V. CONCLUSION

288 This study demonstrates that DAS can be successfully applied to passive acoustic moni-
289 toring of sound-producing fish species under real-world conditions. By transforming existing
290 fiber-optic infrastructure into dense sensor networks, DAS overcomes many of the limita-

291 tions of traditional hydrophone-based monitoring, particularly in terms of spatial coverage,
292 temporal continuity, and logistical cost. The field experiment off Monaco confirmed that
293 DAS can reliably detect and differentiate species-specific calls, track their spatio-temporal
294 distribution, and characterize ambient noise conditions.

295 While conventional hydrophones remain superior at higher frequencies and for fine-
296 resolution pulse detection, DAS offers unique advantages in terms of scalability and in-
297 tegration with existing submarine cables. The observed limitations—such as sensitivity at
298 frequencies above 1 kHz, coupling with heterogeneous seafloor substrates, and large data
299 volumes—represent technical challenges that can be addressed through advances in fiber
300 design, interrogator technology, and automated signal analysis.

301 Beyond fish biophony, DAS holds promise as a holistic ecological observatory, simultane-
302 ously capturing information on surface gravity waves, seafloor currents, and other physical
303 processes that shape marine ecosystems. In an era of accelerating biodiversity loss and cli-
304 mate change, the ability to leverage global submarine cable networks for continuous, large-
305 scale monitoring offers an unprecedented opportunity to bridge critical data gaps. Thus,
306 DAS stands as a complementary and transformative tool for next-generation ocean observa-
307 tion, with direct applications to contribute to knowledge acquisition, marine conservation,
308 resource management, and a better understanding of ecosystem resilience.

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317 **AUTHOR DECLARATIONS**

318 **Conflict of Interest**

319 The authors have no conflicts to disclose.

320 **DATA AVAILABILITY**

321 The data that support the findings of this study are available from the corresponding
322 author upon reasonable request.

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