

The proposal for external users application to SOCIB Glider Facility will have to follow the enclosed template. SOCIB strongly encourages potential users to contact gliders facility ([glider.access@socib.es](mailto:glider.access@socib.es)) to discuss details of existing glider fleet, sensors, feasibility of the proposed mission, etc...

## **SOCIB Gliders**

### **Application Form for External Scientific Users**

## PART 1: User group details

Indicate if the proposing user group is best described as

- ☐ An individual user  
☒ A team of two or more users

### Information about the applicants (PI and project partners)

#### Principal Investigator (user group leader)

Title, Name and Surname: Prof. Eric Parmentier  
 Gender: male  
 Institution: University of Liege  
 Department / Research Group: Laboratoire de Morphologie Fonctionnelle et Evolutive (MORFONCT)  
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 Email: e.parmentier@uliege.be  
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#### Project partners

(repeat for each partner of the group)

Title, Name and Surname: Dr Marta Bolgan  
 Gender: female  
 Institution: University of Liege  
 Department / Research Group: Laboratoire de Morphologie Fonctionnelle et Evolutive (MORFONCT)  
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## PART 2: Additional information about the applicant(s) expertise

### **Relevant expertise of the user group (max. 200 words)**

An important research subject at MORFONCT **aims to determine the fundamental components of acoustic communication** (sound production and hearing) **in fishes and their evolution**. The studies **integrate data in (functional) morphology, acoustic, physiology, behaviour, biogeography and ecology**. The team possesses deep knowledge of Ophidiiformes, which is probably the fish order with the widest depth range. More importantly, the team gathers different skilful scientists (Dr. Bolgan, Dr. Bertucci, Dr. Kéver and Raick), all having in-depth knowledge in the field of acoustic communication of marine fish. MORFONCT has also long-term and fruitful collaborations with different European laboratories working on fish communication (e.g. CHORUS team in France; the Acoustic Communication Lab at the University of Lisbon, Portugal).

During 2017 and 2018, we assessed the occurrence of fish sounds in the Mediterranean submarine canyon of Calvi (France) thanks to a combination of Static Acoustic Monitoring and of gliders. This study, currently in review in the Journal of Acoustic Society of America, proves the feasibility of vocal fish monitoring by using hydrophone-integrated gliders. In 2019, the user group started a collaboration with SOCIB (thanks to a TNA-Jericonext, 3<sup>rd</sup> call). Unfortunately, the datalogger failed. A new, improved datalogger is now available to the user group.

### **Short CV of the PI (max. 200 words)**

I began to investigate acoustic communication in fish during my PhD thesis (defence in 2003). Since then, I have continued to investigate several complementary aspects of the emission and reception of sounds in fish, thanks also to several research stays in the United States (Commonwealth Virginia University, Prof. M.L. Fine and University of South Florida, Prof. D.A. Mann). In September 2007, I became a F.R.S-FNRS Research Associate at the University of Liege. I was subsequently appointed lecturer and Director of the Functional and Evolutionary Morphology Laboratory (MORFONCT). I am now a full professor.

I have carried out many field trips in French Polynesia, Chili, Corsica, Madagascar, Taiwan and USA which allowed me to develop and in-depth and worldwide knowledge of vocal fish species and of underwater ecosystems in more general terms. So far, I have authored or co-authored 158 international peer-reviewed publications, I have organized two international congresses in ichthyology, I have authored or co-authored more than 120 oral or poster communications during international congresses, I have received 9 scientific distinctions/awards and I have directed 51 MSc thesis and 13 PhD thesis.

### **A list of 5 recent, relevant publications of the user group**

- Parmentier, E., Bahri, M. A., Plenevaux, A., Fine, M. L., & Estrada, J. M. (2018). Sound production and sonic apparatus in deep-living cusk-eels (*Genypterus chilensis* and *Genypterus maculatus*). Deep Sea Research Part I: Oceanographic Research Papers, 141, 83-92.
- Fine, M. L., Ali, H. A., Nguyen, T. K., Mok, H. K., & Parmentier, E. (2017). Development and sexual dimorphism of the sonic system in three deep-sea neobythine fishes and

comparisons between upper mid and lower continental slope. Deep Sea Research Part I: Oceanographic Research Papers 131: 41-53.

- Parmentier E, Di Iorio L, Picciulin M, Malavasi S, Lagardère JP, Bertucci F (2017). Consistency of spatio-temporal sound features supports the use of passive acoustics for long-term monitoring. Animal Conservation doi:10.1111/acv.12362.
- Parmentier E, Diogo R, Fine ML (2017). Multiple exaptations leading to fish sound production. Fish and Fisheries 18: 958-966.
- Ruppé L, Clément G, Herrel A, Ballesta L, Décamps T, Kéver L, Parmentier E (2015). Environmental constraints drive the partitioning of the soundscape in fishes. Proceedings of the National Academy of Science (PNAS) 19: 6092-6097.

### PART 3: Detailed scientific description of the project

#### List the main objectives of the proposed research

(max. 300 words)

The overarching question of this project (DEFPAM-G) is: **can we couple Passive Acoustic Monitoring (PAM) to glider technology for monitoring fish populations in the Balearic Sea?**

The underling hypothesis is that fishes living in deep waters **have evolved to use sounds to re-connect and communicate**. Monitoring these sounds can provide important insights about fish life history, cycles of activities and movements. We expect that Mediterranean deep-sea fish present modification of the morphological structures enabling sound production due to decreasing food supplies and increasing hydrostatic pressure, as recently shown in deep-sea neobythitine fish of the Philippine Sea and of the North-Western Atlantic by the PI and colleagues and by other studies carried out on Macrourinae and Ophidiiformes spp. In particular, **we expect to find a spatial and depth variation of fish sounds, highlighting spatial partitioning of breeding sites among species, as well as diversity and abundance variations related with depth.**

**The specific objectives of DEFPAM-G are:**

- 1) Testing the performance of the **acoustic datalogger of property of the PI** to pressure typical of depths of max. 970 m (**Work-package 1**)
- 2) **Coupling PAM to the glider technology for mapping spatial and depth patterns of deep-sea fish vocal populations in the Balearic Sea (Work-package 2)**
- 3) **Sound description**, characterisation of **spatial and temporal occurrence of sounds**, correlation of acoustic features with **environmental factors** (such as temperature) and inferring of the potential **vocal fish species**. **Final sound library creation (Work-package 3).**

#### Give a brief description of the scientific and/or technical background to, and rationale for, your project

Sound travels five times faster in water than in air [1] and it is therefore the ideal communication signal to be exploited by aquatic animals. More than 800 fish species have evolved morphological adaptations allowing them to produce species-specific sounds, which are especially conspicuous during reproductive interactions [2]. Passive Acoustic Monitoring (PAM) involves the use of hydrophones to record all components of underwater soundscapes, including fish calls [3]. **PAM represents a non-invasive way to assess temporal and spatial patterns of distribution of**

**calling fish**; it has been used to investigate **presence, distribution, relative abundance, diel, lunar and seasonal cycles of activity** as well as for **delimitating spawning areas and studying wild fish spawning behaviour** [4-14]. Currently, PAM has been almost exclusively used to monitor coastal fish populations [4-14]. Although anatomical studies undertaken on different fish taxa show that many deep-sea fish should be able to emit sounds as they possess the required mechanisms [15-20], very little descriptions of deep-water fish sounds are available. A first onomatopoeia description of *Coelorinchus caelorhincus* sounds was given by Bonaparte [21]. Since then, few PAM studies have been attempted on the continental shelf and upper slope in the Bahamas, in the Gulf of Mexico and in the Gulf of Maine [22-27]. From these studies, it appears evident that **a fundamental requirement for a successful PAM of deep-sea fish is a type of deployment which minimizes self-noise** [23-24]. **Autonomous gliders are a relatively new technology for studying oceanography over large time and space scales** [25-27]. Although it appears that the innovative technology provided by gliders can be a successful approach for monitoring wild fish populations, no attempt has ever been made to record fish sounds across large spatial scale in the Balearic Sea by using gliders.

Several European deep-sea fish belong to families with known vocal abilities, i.e. **Macrouridae, Ophidiidae, Brotulidae, Sebastidae and Triglidae**. Although the Mediterranean fauna remains largely unstudied [28], the biodiversity between -200 m and -4000 m would include more than 100 fish species [28-31]. In the Balearic Sea, in the depth range of DEFPAM-G (upper- middle slope waters up to a max of 970 m depth), **a clear depth zonation of the structure and of the spatial distribution of fish assemblages has been described** [31]. The fish community between -200 and -600 m is dominated in abundance and biomass by the blackbelly rose fish ***Helicolenus dactylopterus* (Sebastidae, Scorpaeniformes)** [31]. As the presence of sound production mechanisms has been documented in other Sebastidae species [32-34] and Sebastidae courtship and agonistic sounds have been described [35], we hypothesize that also *H. dactylopterus* emit sound for communication purposes and that its sounds will have similar features to those of other Sebastidae spp. (i.e. POP: single, discrete beat; GROWL: short call consisting of a series of rapid beats with descending fundamental frequencies and amplitudes and RUMBLE: calls longer than two seconds typically containing more than 75 pulses [35]).

Furthermore, in the Balearic Sea, both above and below -600 m, species belonging to the **Macrourinae sub-family (Macrouridae, Gadiformes)** are **between the most abundant fish species** (i.e. up to 600 m depth the rougthead grenadier ***Nezumia schlerorynchus***, in the middle slope ***Nezumia aequalis*** and the Macrouridae ***Thrachyrhynchus scabrous***) [31]. Macrourinae males of the same genus (i.e. *Nezumia*) possess large sonic muscles surrounding the swimbladder that are undoubtedly devoted to sound production [15-16]. We therefore hypothesize to record long, low-frequency drumming and humming sounds (similar to those of other coastal Gadiformes species [36-37]), especially at depths below -600 m. As in the Catalan Sea *Nezumia aequalis* show a **continuous reproductive cycle** [38], we expect that the possibility of recording Macrourinae sounds is equally distributed between summer and winter months.

Other two important deep-water families are the cusk-eels (**Ophidiidae**) and the closely related Brotulidae, which are also reported to possess large sonic muscles and swim-bladders [18-20] and to be abundant in the Catalan sea. Sound production in these families has been reported for shallow water species (*Ophidion marginatum* [39-40] and *O. rochei* [41-42]).

#### References:

- [1] Urlick. 1984. WA: Undersea Warfare Technology Office, Navy [2] Mann et al. 2016. In: Listening in the Ocean, New York: Springer; pp. 309-324. [3] Rountree et al. 2006. Fisheries 31(9): 433-446. [4] Mann & Lobel 1995. Bioacoustics 6(3): 199-213. [5] Locascio & Mann D.A. 2008. T Am Fish Soc 137:606-615. [6] Luczkovich et al. 2008. T Am Fish Soc 137: 576-605. [7] Fine & Thorson. 2008. T Am Fish Soc 137:627-637. [8] Gannon & Gannon J.G. 2009. Fish Bull 108(1): 106-116. [9] Hernandez et al. 2013. ICES J Mar Sci 70(3):628-635. [10] Picciulin et al. 2013. Fish Res 145: 76-81. [11] Picciulin et al. 2013. Bioacoustics 22(2): 109-120. [12] Wall et al. 2013. Mar Ecol Prog Ser 484: 173-188. [13] Gannon. 2008. T Am Fish Soc 137:638-656. [14] Luczkovich et al. 1999. Bioacoustics 10:143-160. [15] Marshall. 1954. Philosophical Library, New York. [16] Marshall. 1967. In: Tavoiga, W.N. (Ed.), Marine Bio-Acoustics. Oxford: Pergamon Press, pp. 123-133. [17] Fine et al. 2007. J Morph 268: 953-966. [18] Nguyen et al. 2008. Biol Lett 4: 707-710. [19]

Ali et al. 2016. Deep-Sea Res Part I: 115, 293–308. [20] Fine et al. 2017. Deep Sea Res Part 1 Oceanogr Res. doi.org/10.1016/j.dsr.2017.11.009. [21] Bonaparte. 1832. Rome: Salviucci. [22] Mann & Jarvis. 2004. J Acoustic Soc Am: 115(5), 2331–2333. [23] Rountree & Juanes. 2010. Cur Zool, 56(1): 90–99. [24] Rountree et al. 2012. In The Effects of Noise on Aquatic Life. New York; Springer. [25] Wall et al. 2014. Deep-Sea Res I: 57–64. [26] Wall et al. 2012. Mar Ecol Prog Ser 449: 55–64. [27] Wall et al. 2017. Mar Coast Fisheries 9: 23–37. [28] Danovaro et al. 2010. PLoS ONE 5(8). [29] Priede I.G. 2017. Cambridge University Press. [30] Ruiz. 2009. J Mar Sys 78: S3–S16. [31] D'Onghia et al. 2004. Scientia Mar 68(3): 87–99. [32] Hallacher (1974). Proc Calif Acad Sci 540:59–86 [33] Širović et al. 2009. ICES J Mar Sci 66: 981–990. [34] Širović & Demer. 2009. Copeia 2009: 502–509. [35] Nichols, B. (2005). University of South Florida Theses and Dissertations, 1–55. [36] Hawkins & Rasmussen. 1978. J Mar Biol Ass UK 58: 891–911 [37] Casaretto et al. 2015. J Fish Biol 87(3): 579–603. [38] Fernandez-Arcaya et al. (2013). Deep Sea Research Part II 92, 63–72. [39] Mann et al. 1997. Copeia 1997(3): 610–612. [40] Rountree & Bowers-Altman. 2002. Bioacoustics 12: 240–242. [41] Parmentier et al. 2010. J Exp Biol 213: 3230–3236. [42] Kéver et al. 2016. Mar Ecol 37(6): 1315–1324

**Present the proposed experimental method and working plan with detailed information on the number of gliders requested, the sensors needed, mission plan, maximum depth (200 or 1.000 m).**

**(max. 500 words)**

### **WORK- PACKAGE 1: Testing the pressure performance of the acoustic datalogger of property of the PI**

MORFONCT has recently acquired a small self-contained acoustic datalogger which can acquire acoustic data in continuous or over a duty cycle for the entire deployment period (ca. 20 days). It is worth to mention that Loggehead Instruments has provided also the self-contained dataloggers used in two of the other reported PAM of fish population coupled with glider technology. The close collaboration with Loggerhead will be important during the initial phases of DEFPAM-G, in order to implement quick solution to any problem that might arise. During the initial phases of DEFPAM-G, the user group will visit SOCIB for a first meeting and for testing the datalogger performance to high depths in the pressure test site at SOCIB.

### **WORK- PACKAGE 2: Coupling PAM to the glider technology for mapping deep-sea fish in the Balearic Sea**

The access to a deep-water glider is requested for a total period of about 20 days. The expertise of the engineering team at SOCIB is fundamental for the successful achievement of this work package, while the presence of the user group is mandatory during the phases of preparation of the glider mission and of launching in order to program and to start the datalogger. In particular;

**Mission Preparation:** The deep-glider will be prepared and a specialized technician from SOCIB will manage laboratory operations (BCB integration, ballasting, calibration, informatics, data management and other required operations).

**Survey:** We plan to deploy the BCB on the glider along the glider routine line of SOCIB in the Ibiza channel (Spain) and, possibly to extend this survey to adjoining areas of the Balearic Sea, for a period of ca. 58 days (June 2020). The datalogger will be scheduled to provide acoustic data on a duty cycle of 3 min every 10, continuously over the 24 hours.

**Conclusion:** After the glider mission, the glider and the datalogger will be retrieved. Data will be backup and linked to the other data collected from the glider in-board instrumentation (e.g. temperature and depth profiles).

### **WORK- PACKAGE 3: Sound description and inferring the potential vocal fish species. Sound library creation**

The audio data will be first analysed by the user group. Manual analysis will be carried out to characterise in detail calls having the typical feature of fish sounds (by measuring several acoustic features, e.g. number of pulses, pulse period, peak frequency etc). This will allow 1) to characterise the sound types and to cluster them into homogeneous and mutually exclusive groups; 2) to investigate their spatial and depth variation, as well as the relationship between acoustic features and environmental factors (e.g. temperature). The identity of the sound emitter will be inferred by comparing the sound features to those reported in literature for closely related shallow water species. We will produce the first library of deep-sea fish sounds, which will be freely available (i.e. uploaded on ULiège and SOCIB outreach platforms).

**Indicate the type of access applied for**

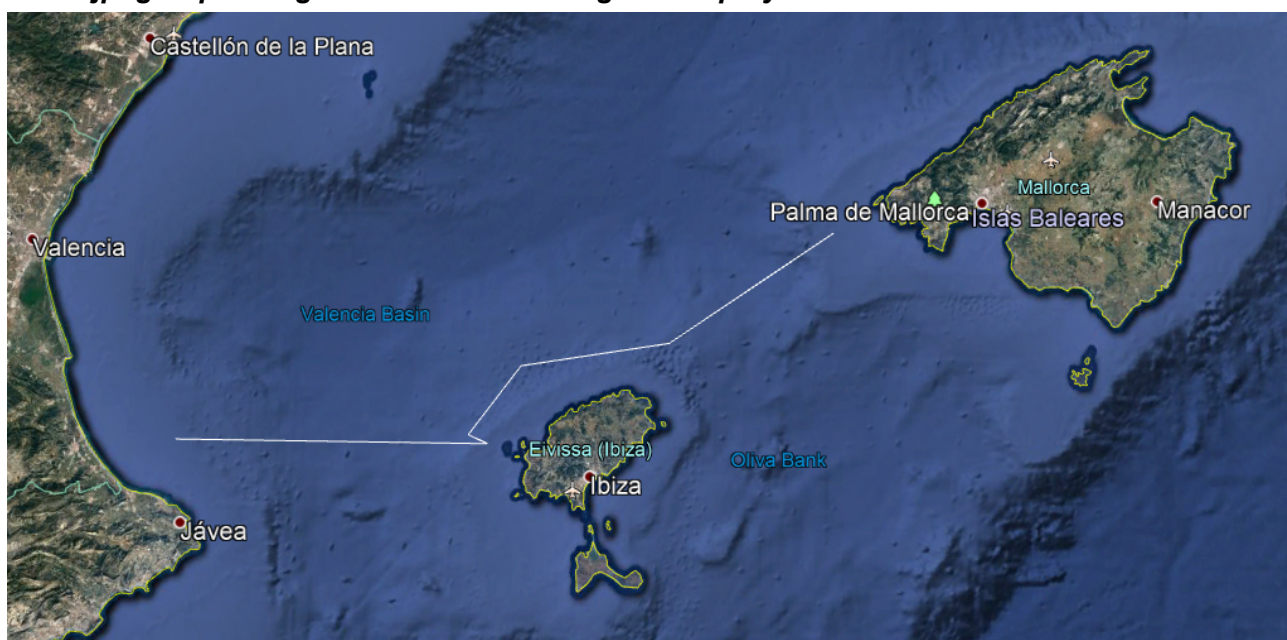
- ☐ remote (the measuring programme is implemented by SOCIB and the presence of the user group is not required)
- ☒ partially remote (the presence of the user group is required at some stage)
- ☐ 'in person/hands on' (the presence of the user group is required / recommended during the whole access period)

**Indicate the proposed time schedule including expected duration of access time**

(max. 200 words)

The mission will be one of the standard canales mission of SOCIB; proposed date from June 9th to August 6th, 2020 (58 days).

**Add a jpeg or pdf diagram of the idealised glider deployment track**



**Additional information**

**Is there another facility in your country similar to the one you wish to utilize?**

☐ Yes ☒ No

**If yes, please indicate your reasons for requesting access to the SOCIB glider (max. 150 words)**

**Is this a resubmission of a previously rejected proposal?**

☐ Yes ☒ No

<b><i>If yes, please provide the reference number and submission date of the original proposal. Briefly describe the changes made in comparison to the rejected version (max. 200 words)</i></b>
<b><i>Is this a continuation of an earlier successful project?</i></b>
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
<b><i>If yes, please provide the reference number and submission date of the earlier proposal. Briefly describe the principle achievements of the earlier project and any objectives that were not fully met. (max. 200 words)</i></b>


<b>PART 4: Technical information</b>
<b><i>List of the glider instrumentation of most importance to your proposal</i></b>
A <a href="http://www.teledynemarine.com/slocum-glide">deep-water glider</a> ( <a href="http://www.teledynemarine.com/slocum-glide">http://www.teledynemarine.com/slocum-glide</a> ) <a href="#">operating in the Ibiza Channel Monitoring Line (max depth 970 m) is requested</a> . An intensive collaboration with technicians and engineers from the glider facility during pressure tests, preparation of the mission, survey and conclusion, as well as cooperation with the SOCIB data centre (for linking the acoustic data to the temperature and depth profiles), are fundamental requirements for the successful achievement of the DEFPAM-G objectives.
<b><i>List of any additional instrumentation that you have discussed and agreed with the Glider Facility</i></b>
Not applicable
<b><i>Provide details of your preferred sampling intervals, glider excursion depths and surfacing/communication intervals</i></b>
As for the standard canales sampling
<b><i>Details of your Data Management specific needs.</i></b>
Not applicable
<b><i>Risk Evaluation (marine traffic, fishing grounds, etc.) and Contingency Plan</i></b>

#	Risk / Contingency	Prevention / Mitigation / Corrective action
1	Electronical or deployment related failures of the BCB	1) work in close collaboration with the company producing the BCB (i.e. Loggerhead): timely adjustments to the recording equipment, if required; 2) work in close collaboration with the engineer team at SOCIB: timely adjustments to the glider integration, if required;
2	Glider collision with boats and fishing activities	Tools are available at SOCIB to minimize the risks of collision when crossing the main traffic routes as monitored by historical and real time AIS data.
3	Glider functioning anomaly	Possibility to activate emergency logistic through the use of the SOCIB zodiac-hurricane boat.

***Emergency Logistics for immediate recovery (time to action, radius of action planed, etc.)***

Date of compilation 27/03/2020

Signature of the PI



***This section reserved for the SOCIB Glider Facility***

Date of proposal receipt by email

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Assigned reference number

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Signature of receiving officer

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