Long-term monitoring projects of Brazilian marine and coastal ecosystems

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Biodiversity assessment is a mandatory task for sustainable and adaptive management for the next decade, and long-term ecological monitoring programs are a cornerstone for understanding changes in ecosystems. The Brazilian Long-Term Ecological Research Program (PELD) is an integrated effort model supported by public funds that finance

ecological studies at 34 locations. By interviewing and compiling data from project coordinators, we assessed monitoring efforts, targeting biological groups and scientific production from nine PELD projects encompassing coastal lagoons to mesophotic reefs and oceanic islands. Reef environments and fish groups were the most often studied within the long-term projects. PELD projects covered priority areas for conservation but missed sensitive areas close to large cities, as well as underrepresenting ecosystems on the North and Northeast Brazilian coast. Long-term monitoring projects in marine and coastal environments in Brazil are recent (< 5 years), not yet integrated as a network, but scientifically productive with considerable relevance for academic and human resources training. Scientific production increased exponentially with project age, despite interruption and shortage of funding during their history. From our diagnosis, we recommend some actions to fill in observed gaps, such as: enhancing projects' collaboration and integration; focusing on priority regions for new projects; broadening the scope of monitored variables; and, maintenance of funding for existing projects.

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Abstract

56   Biodiversity assessment is a mandatory task for sustainable and adaptive management for the next
57 decade, and long-term ecological monitoring programs are a cornerstone for understanding changes in
58 ecosystems. The Brazilian Long-Term Ecological Research Program (PELD) is an integrated effort model
59 supported by public funds that finance ecological studies at 34 locations. By interviewing and compiling
60 data from project coordinators, we assessed monitoring efforts, targeting biological groups and scientific
61 production from nine PELD projects encompassing coastal lagoons to mesophotic reefs and oceanic
62 islands. Reef environments and fish groups were the most often studied within the long-term projects.
63 PELD projects covered priority areas for conservation but missed sensitive areas close to large cities, as
64 well as underrepresenting ecosystems on the North and Northeast Brazilian coast. Long-term monitoring
65 projects in marine and coastal environments in Brazil are recent (< 5 years), not yet integrated as a
66 network, but scientifically productive with considerable relevance for academic and human resources
67 training. Scientific production increased exponentially with project age, despite interruption and shortage
68 of funding during their history. From our diagnosis, we recommend some actions to fill in observed gaps,
69 such as: enhancing projects' collaboration and integration; focusing on priority regions for new projects;
70 broadening the scope of monitored variables; and, maintenance of funding for existing projects.
71

Introduction

73   Ecological monitoring can provide valuable information for the management and sustainability of
74 ecosystems, including our survival in the face of increasing changes in ecosystem functioning and
75 degradation of ecological services (Lindenmayer & Likens, 2009). Such biodiversity monitoring is
76 paramount in order to act before and while changes are still manageable by implementing thresholds and
77 warning systems, guiding restoration, and building efficient natural observatories (Canonico et al., 2019).
78 Thus, reliable data from monitoring efforts depends on optimal planning and data management to
79 maximize its usage and ensure its longevity (Magnusson et al., 2013, Canonico et al., 2019).
80   Long-term ecological monitoring is an essential tool to raise red flags about declining
81 populations, changes in species distribution, structure and stability of food webs, increase in functional
82 vulnerability and risk of species extinction (Gaiser et al., 2020; Lindenmayer & Likens, 2009) helping to
83 track ecosystem shifts. Long-term monitoring is also essential to understand ecosystem dynamics and
84 ecological processes at different levels of organization and across scales (Norström et al., 2009; Cruz et
85 al., 2015), as well as a proving ground to evaluate marine protected areas (MPAs) effectiveness (Roos et
86 al., 2020) and forecast changes in ecosystems (Capitani et al., 2021). Globally, monitoring efforts are
87 mostly associated with Northern Hemisphere biomes following the scientific historical background of

88   economically developed countries (Mirtl et al., 2018; Muelbert et al., 2019). Therefore, the Global South
89   should be considered a priority region for establishing monitoring projects due to its high biodiversity,
90   ongoing degradation and sparse long-term initiatives.
91   The Brazilian Long-Term Ecological Research Program (*Programa de Pesquisas Ecológicas de*
92   *Longa Duração* – PELD, in Portuguese) was conceived in 1997 to support long-term research and
93   monitoring in Brazil (Barbosa, 2010) and is a national effort funded by the Brazilian government and
94   coordinated by the CNPq (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*, in
95   Portuguese). PELD is a member of the ILTER (International Long-Term Ecological Research) network
96   encompassing 44 countries and 700 research sites in a variety of ecosystems across the planet (Mirtl et al.,
97   2018), of which 63 are coastal and 52 are marine sites (Muelbert et al., 2019; 2020). Currently, there are
98   34 active PELD sites in Brazilian territory, nine of which are in marine or coastal habitats (Brito et al.,
99   2020).
100   As we enter the United Nations Decade of Ocean Science for Sustainable Development (2021 –
101   2030 Ocean Decade), clean, accessible, and resilient oceans are key to achieving Sustainable
102   Development Goals (Heymans et al., 2020; Visbeck, 2018). Brazil's role in monitoring marine and
103   coastal ecosystems is crucial since its jurisdictional waters represent a large part of the South Atlantic
104   Ocean, and harbor unique ecosystems such as the Abrolhos Bank reef complex (Leão & Kikuchi, 2001),
105   the Rocas Atoll (Longo et al. 2015), and the Great Amazon Reef (Moura et al., 2016). In early 2020,
106   experts involved in monitoring marine and coastal ecosystems from PELD projects took part in a
107   workshop to compile the information and scientific production generated by those monitoring nuclei. The
108   meeting aimed to create a "state of the art" of those monitoring sites and build a framework for future
109   combined efforts and collaboration. This manuscript is one of the products of the first "Workshop for
110   Integration of Time Series from Brazilian Marine Ecosystems – Long-Term Ecological Program
111   (PELD)". Using an expert group workflow, we investigated the main characteristics of long-term
112   monitoring projects established in Brazilian coastal and marine environments to highlight their main
113   scientific outputs, funding issues and human resources, as well as the spatial and temporal scales covered
114   by these initiatives. From that picture, we point out spatial gaps and collaboration strengths to help frame
115   future directions for the long-term monitoring of marine and coastal ecosystems in Brazil. Furthermore,
116   we show a picture of the largest country in the Global South, representing a considerable part of the
117   southern Atlantic shores within a single national jurisdiction, which may benefit other countries with
118   similar challenges in monitoring marine and coastal areas.
119

Material and Methods

121   Coordinators of PELD projects from coastal and marine areas (until 2019) and experts in marine
122   biological monitoring from Brazilian universities were invited to participate in the workshop. We did not
123   include individual monitoring efforts such as programs supported by oil companies and other mixed-
124   funds sources due to their major focus on umbrella species. We restricted our data to research groups
125   linked to PELD projects to evaluate the functioning of a national-level funding program with expansion
126   potential. In total, twenty-eight researchers from 16 universities and research institutes from eight states
127   and the Federal District attended the workshop. These researchers contributed with data from nine
128   projects of PELD program (Table 1S) which had completed more than 5 years of uninterrupted sampling,
129   irrespective of frequency (annual, monthly, weekly etc.). The workshop was divided into three phases:

130   1. Identification of the temporal and spatial scales of the monitoring programs, and their
131   monitored variables. This part aimed at making a diagnosis of the overlapping targets of
132   monitoring projects and their history;
133   2. Evaluation of possible approaches to the analysis of time series. Here, we aimed at
134   investigating which broad ecological questions and challenges associated with climatic
135   changes can be tackled in this conjunct effort;
136   3. Implementation of strategies for the execution of scientific deliverables from the existing
137   data. Lastly, we aimed at proposing coordinated actions for sustainable management of
138   marine areas in Brazil based on the previous outputs, strengths, and gaps of current
139   monitoring knowledge in an integrated effort with environmental agencies and stakeholders
140   from monitoring locations.

141

142   The following indicates the results of the workshop's first phase and they were based on
143 information collected from coordinators and collaborators of PELD projects regarding temporal and
144 spatial scales over which they operate. Phases 2 and 3 are still in development and will not be treated
145 here. Data from each project was obtained by direct structured interviews with coordinators and
146 complemented by answering digital forms (Google Forms®) sent after the meeting (Table 2S). The
147 questions addressed involved (1) details of each PELD project, including the number of researchers,
148 students and partner institutions involved, (2) the biological and physical components monitored by each
149 project, (3) funding information, and (4) scientific contribution and human resources formation. The
150 complete questionnaire with all evaluated variables can be found in the supplementary material (Table
151 2S). It is worth noting that we did not evaluate differences in methods applied for monitoring the
152 variables because that varied considerably among projects and, sometimes, methods changed within the
153 same project throughout its history.

154   We applied generalized linear models (GLMs) to assess the relationship between scientific
155 production and project monitoring time using log as a link function to adjust to the Poisson distribution of
156 scientific production. GLMs were run using the *glm* function from the *stats* package in R software (R
157 Core Team 2020). We built a network of projects partners based on direct relationships between
158 institutions associated with projects as indicated by coordinators and collaborators in the digital forms.
159 From the network, we calculated four global metrics based on an undirected network: transitivity,
160 modularity, connectance, and centralization. Transitivity measures the probability that the adjacent
161 vertices of a node are connected (Wasserman et al., 1994). Modularity describes a compartmentalized
162 distribution of interactions among projects (*e.g.*, Olesen et al., 2007). Connectance is the proportion of
163 realized links relative to all the possible links in the network (Boccaletti et al., 2006), and centralization
164 represents the heterogeneity in the distribution of institutions and projects. Associations were evaluated
165 using the *igraph* package (Csardi & Nepusz, 2006), and graphs were plotted using *ggplot2* package
166 (Wickham 2016).

167

168   Results

169   Twelve monitoring locations from nine projects (some PELD projects monitor more than one site,
170 such as PELD ILOC which monitors four sites) within the PELD program were identified along ~3,200
171 km of the Brazilian coast, from Pernambuco to Rio Grande do Sul (Figure 1). A 2,000 km gap was found
172 in the north and northeast coastal regions (from Amapá to Rio Grande do Norte), and another 1,000 km
173 gap was observed in the southeast region (from São Paulo to Rio Grande do Sul; Figure 1). Habitats

174 monitored by the research groups mainly included subtidal ecosystems, while terrestrial elements (coastal
175 vegetation and fauna) were studied only in two programs (Table 1S). Shallow areas (< 50 m deep) with
176 reef environments (biogenic and non-biogenic) were the most frequently and widespread surveyed
177 habitats (six of nine projects, Table 1S). The distribution of reef environments included both tropical and
178 subtropical domains and all Brazilian oceanic islands. Unconsolidated substrate habitats were monitored
179 in four out of nine projects (Table 1S) in shallow coastal habitats. All evaluated PELD projects lie within
180 or in the vicinity of MPAs (Table 1S).

181 Monitoring targets varied among projects and represented different levels of organization (Table
182 5S) such as communities (e.g., benthic community, zooplankton), assemblages (e.g., ichthyofauna), and
183 key taxa locally monitored by some PELD projects (e.g., the structuring coastal vegetation *Clusia* sp., and
184 the scleractinian coral *Montastraea cavernosa*). Reef fish were the biological indicator with the greatest
185 spatial extent in monitoring, covering tropical and subtropical domains (Figure 1, Table 3S), and
186 monitored in 89% of PELD locations. The aquatic flora (macroalgae and/or seagrass) and sessile
187 invertebrates were frequent groups in monitoring initiatives (67%). The coastal vegetation (mangrove
188 forests and/or restinga sand vegetation) and the mobile invertebrate fauna were monitored sparsely along
189 the coast. Neritic components (*e.g.*, phytoplankton, zooplankton, marine mammals) were mostly
190 monitored at southern locations, while socio-economic indicators were monitored at northeastern sites
191 (*i.e.*, CCAL, Abrolhos and TAMS; Figure 1, Table 5S).

192 Most of the PELD monitoring projects had short temporal data sets (median = 12 years, Q1 = 6,
193 Q3 = 22), with the longest time associated with the *Lagoa dos Patos* PELD (since 1993, 29 years). The
194 longest time series was associated with the monitoring carried out by the Brazilian Navy's Sea Studies
195 Institute, the *Instituto de Estudos do Mar Almirante Paulo Moreira* (IEAPM) in Arraial do Cabo, which
196 started in 1974, but was only funded as a PELD site in 2016. All sites had, at least, an annual monitoring
197 frequency since the start of projects (Figure 1, Table 1S), although some had a greater frequency during
198 part of the monitoring period (weekly = 11.1%, monthly = 44.4% or quarterly = 66.6%, during a couple
199 of years). The plankton-associated groups had the longest monitoring time, especially associated with the
200 oldest locations (ELPA = 29 years, and PEBG = 25 years). 'Others' consisted of temporal monitoring
201 describing geochemical processes, multi taxa approaches, stable isotopes, water temperature, reef
202 accretion, carbon stocks and geological aspects which are particular to some PELD locations (Figure 1).

203 The federal agency *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) was
204 the main funding source of PELD projects, followed by state level public funding agencies and the
205 National Education Agency – CAPES (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* in
206 Portuguese). The latter, usually supported programs by supplying Ph.D. and M.Sc. scholarships. The
207 capacity building and training of scientists was a valuable outcome of the programs, accounting for at
208 least 291 PhD and Master's thesis. The results and actions of marine and coastal PELD projects were
209 communicated as scientific peer-reviewed publications (peer-reviewed articles, book and book chapters; n
210 = 530 until January 2020) which constitute a large part of the results of those monitoring efforts (Table
211 4S) and have increased exponentially since monitoring was set up at each site (Figure 2). Scientific
212 events, websites and social media were the most used ways to communicate and disseminate the results
213 from PELD projects, whereas large-scale communication outlets such as broadcast television, newspaper
214 and radio were seldom used (Figure 3).

215 We observed a modular PELD projects network (modularity = 0.18), which was formed by few
216 and poorly connected groups (mean distance between nodes = 3.2) with low centralization (0.31) and low
217 transitivity (0.01). Furthermore, we observed few connections between groups of nodes (triads), *i.e.*

218 institutions. The PELDs ELPA (n = 20), RLaC (n=13) and PEBG (N=11) had the highest number of
219 direct connections (*i.e.*, degree), but 61.4% were with single nodes. The largest subgroup detected was
220 formed by *Universidade Federal do Ceará* (UFC), *Instituto Chico Mendes de Conservação da*
221 *Biodiversidade* (ICMBio), PELD-ELPA and PELD-TAMS, indicating the low number of shared vertices
222 among network components. A maximum of four nodes shared between PELD nuclei was observed,
223 despite being located along the coast and some sharing the same target habitats (figure 4). The
224 *Universidade Federal Fluminense* (UFF), ICMBio and *Universidade de São Paulo* (USP) were all
225 connected to five PELD sites each. Governmental institutions accounted for only 12.5% of nodes and
226 were more associated with northeastern PELD sites. Older projects (> 20 years) had more international
227 collaborators (75% of all) but shared few connections with other PELD sites (Figure 4). NGOs were
228 connected to only two nodes (4%) of all connections.

229

Discussion

231   Long-term monitoring projects in the Brazilian marine environment are recent, poorly connected,
232 but scientifically productive with an important contribution to academic and human resources training.
233 Long-term ecological monitoring programs seek to give the planned return after several years of existence
234 (Caughlan & Oakley, 2001) because the questions raised by this model of ecological research require long
235 time series to allow temporal patterns to emerge (Giron-Nava et al., 2017). The exponential growth in the
236 scientific production of PELD projects was not surprising as it has also been observed for terrestrial
237 LTER (Randig, 2019). After the settling phase, established experience, network and infrastructure give
238 support for knowledge building and the formation of qualified human resources. Thus, efforts and
239 investment in such programs have a key role and contribution to scientific advancement, with a legacy of
240 human resources and networking, which will boost policymaking outcomes (Hughes et al., 2017).

241   Changes in global environmental stability and their effects on biodiversity and ecosystem services
242 are the main concerns of environmental policy (Haase et al., 2018) and monitoring is a key objective.
243 Long-term monitoring programs are essential to detect changes associated with anthropogenic stressors
244 and disentangle the real effects from 'background noise' enabling predictive approaches to ecosystem
245 change (Magurran et al., 2010). Monitoring of Essential Biological (EBVs) and Oceanographic Variables
246 (EOVs) has been one of the aims of global strategies focused on the United Nations Sustainable
247 Development Goals (Kissling et al., 2018). Variables monitored by the PELD projects, such as water
248 temperature, fish and plankton abundance, and macroalgae coverage are within those EOVs and EBVs
249 (Miloslavich et al., 2018). Despite the short time-series of most PELD projects, the monitoring of these
250 key variables at a large spatial scale is advantageous for complying with emerging international efforts on
251 biodiversity monitoring and best practices in globally integrated observing systems.

252   PELD projects included most coastal environments along the Brazilian coast, with monitoring
253 sites targeting different habitats and taxa. Asymmetries in the number of monitored variables and habitats
254 indicated older and more diverse initiatives concentrated on the southern Brazilian coast, where more
255 traditional universities and institutes are established. There are gaps related to estuaries and intertidal
256 areas' representativeness, especially in the North and Northeast regions, leaving aside one of the most
257 extensive mangrove forests in the world (Diniz et al., 2019). Additionally, the absence of offshore and
258 underrepresentation of intertidal and unconsolidated substrate habitats could also stimulate joint efforts to
259 build the ground for such monitoring. On the other hand, reef habitats were better covered by monitoring
260 initiatives, which resulted in an opportunity to increase the interaction among marine and coastal PELD
261 projects; for instance, by establishing standardized methods and efforts for sampling, and developing

262   integrated large-scale experiments. Also, considering the seascape heterogeneity, conjunct and individual
263   monitoring efforts must seek to design protocols to account for such habitat representativeness to allow
264   observing changes at the ecosystem level and facilitating the integration of large-scale analysis. On that
265   matter, benthic cover data and depth are both crucial to identifying seascape features and are already
266   contemplated by projects monitoring reef habitats.

267   Most of the PELD sites were associated with MPAs, many of which are conservation priority
268   areas (Magris et al. 2021). The bias of monitoring locations within protected areas is associated with
269   historical relationships with the MPA´s creation based on management demands and previous scientific
270   knowledge of local ecosystem importance. Thus, knowledge about important and threatened ecosystems
271   outside MPAs, for example, located close to urban areas is missing. Only the PEBG project is located in
272   an important mosaic of ecosystems surrounding a densely populated area, the Rio de Janeiro metropolitan
273   region (IBGE 2018). This indicates poor representation and knowledge gaps in priority areas, raising a
274   red flag for potential targets on the establishment of new monitoring locations and their connectivity. New
275   PELD projects established in 2020 (after the workshop) are now monitoring more important areas in the
276   north (PELD *Sistema de Recifes Mesofóticos da Foz do Rio Amazonas* - GARS), northeast (*PELD Costa
277   Semi-Árida do Brasil*, Ceará) and south coasts (*PELD Sistema Estuarino de Laguna e Adjacências)*).
278   However, the current scenario indicates the need for expanding monitoring sites towards sensitive and
279   underrepresented ecosystems (*e.g.*, mangrove areas in the North region) in a coordinated fashion. Such
280   efforts will also foster the decentralization of monitoring efforts, human resources formation, and
281   financing of related institutions.

282   Continuous financial support is crucial for long-term ecological monitoring programs (Caughlan
283   & Oakley, 2001) and, indeed, it was the main challenge faced by all initiatives present at the workshop.
284   Project coordinators reported unstable financial support, during which only core activities were preserved.
285   The expansion in groups and variables sampled was possible only during less troubled periods – a
286   frequent problem in long-term monitoring (Caughlan & Oakley, 2001). PELD initiatives are at risk
287   because of the continuous depletion of funds for scientific institutions, and the future scenario is bleak
288   (Hallal, 2021). The integration of efforts with other financing sources such as mixed-sourced grants (*e.g.*,
289   Instituto Serrapilheira, Fundação 'O Boticário', FUNBIO) and state-level public funding agencies (*i.e.*,
290   FAPs) may help increase the lifespan of monitoring programs. Also, strengthening and maintaining LTER
291   initiatives may contribute to increasing the odds of consortium-type applications for international grants
292   allowing also widening the scale of questions answered by those programs (Haase et al., 2018). The
293   Ocean Decade and the association of global monitoring programs, such as ILTER and GEO BON
294   (Muelbert et al., 2019), may facilitate the integration of other monitoring efforts and increase the access to
295   new funding. The PELD program is already part of the ILTER scheme and, considering the geographical
296   dimension of Brazil and its ecosystem representativeness, integrated efforts in monitoring marine and
297   coastal ecosystems would help fill a large gap in data in the South Atlantic. Integration efforts should aim
298   at standardizing monitoring protocols and leverage the formation of human resources by providing access
299   to training on best practices of monitoring methodologies, and curating and analyzing data. However, the
300   network analysis indicated that PELD projects have negligible direct interaction mediated by a few
301   institutions, which are not shared by all projects and would not act as a bridge for such integration. This
302   scenario indicates that integration at the national level is the first challenge to be overcome, and the
303   workshop had the role of starting this dialogue since there is no central institution with this vocation.
304   Only PELDs ELPA (Lemos et al. 2022), RLaC (Cardoso et al. 2021) and Abrolhos (Moura et al. 2022)
305   have their datasets available in open repositories (GBIF) which difficult integration, besides

306 methodological differences. Other projects are still in an embargo period but should allocate their data in
307 open repositories after this period, around 2023, creating a fertile ground for collaborations.

308 Best practices on future efforts should include several actions indicated throughout the text and,
309 in general, should include: 1) the creation or adoption of standard and detailed protocols for measuring
310 variables (Beard et al. 1999), preferably following international agreements; 2) detailed recording of
311 methodology and any changes or adaptations made over time; 3) quality assessment and control
312 protocols, including indications of how to deal with issues (*e.g.*, missing or outlier data, taxonomic
313 resolution, calibration procedures etc. – Ellingsen et al. 2017); 4) synchronicity and compatible spatial
314 replicability of measurements (Beard et al. 1999); 5) continuous refreshment on training and integration
315 of personnel from participant groups for leverage; follow open science protocols to guarantee
316 transparency, credibility, replicability and reuse of data (UNESCO 2021); and 6) periodic planning
317 reassessment and reevaluation.

318 Increasing the communication among scientists and monitoring programs is important and to
319 sustain and expand monitoring initiatives. However, the delivery of results and the appropriation of the
320 generated knowledge by society and decision-makers may be the most important aim of all. "The science
321 we need for the ocean we want" is the Oceans Decade motto, and it is a general feeling that it must be
322 taken seriously by those hoping for a sustainable ocean which scientists will be able to monitor for
323 centuries to come. To achieve these goals, our diagnosis supports a few recommendations: 1) enhance
324 integration and collaboration among monitoring projects within the PELD program and other initiatives;
325 2) support existing sites and creation of new ones in vulnerable and underrepresented regions and
326 ecosystems; 3) enhance the collaboration among PELD projects to exchange best practices, assure
327 coverage of EOVs and EBVs and broaden the scope of indicators monitored; 4) guarantee the
328 maintenance of long-term funding for monitoring Brazilian marine ecosystems.

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Figure 1

(A) Map indicating the monitored sites, (B) length of time series (continuous lines before bars indicate monitoring period before PELD support), and (C) general indicators monitored at each long-term monitoring site in the Brazilian coast.

The list of monitored variables can be found in Table 5S in the supplementary material. Polygons in dark blue (A) indicate priority areas for conservation according to Magris *et al.*, (2021). 'others' = may include isotopes, carbon stock, reef accretion and *in situ* primary production. ILOC - *Monitoramento de Longa Duração das Comunidades Recifais das Ilhas Oceânicas Brasileiras*, TAMS – *Tamandaré Sustentável*, CCAL - *Costa dos Corais Alagoas*, HCES - *Habitats Costeiros do Espírito Santo*, RLaC - *Restingas e Lagoas Costeiras do norte do Estado do Rio de Janeiro*, RECA – *Ressurgência de Cabo Frio*, PEBG - *Estrutura e Funções do ecossistema da Baía de Guanabara*, ELPA – *Estuário da Lagoa do Patos e Costa Marinha Adjacente*.
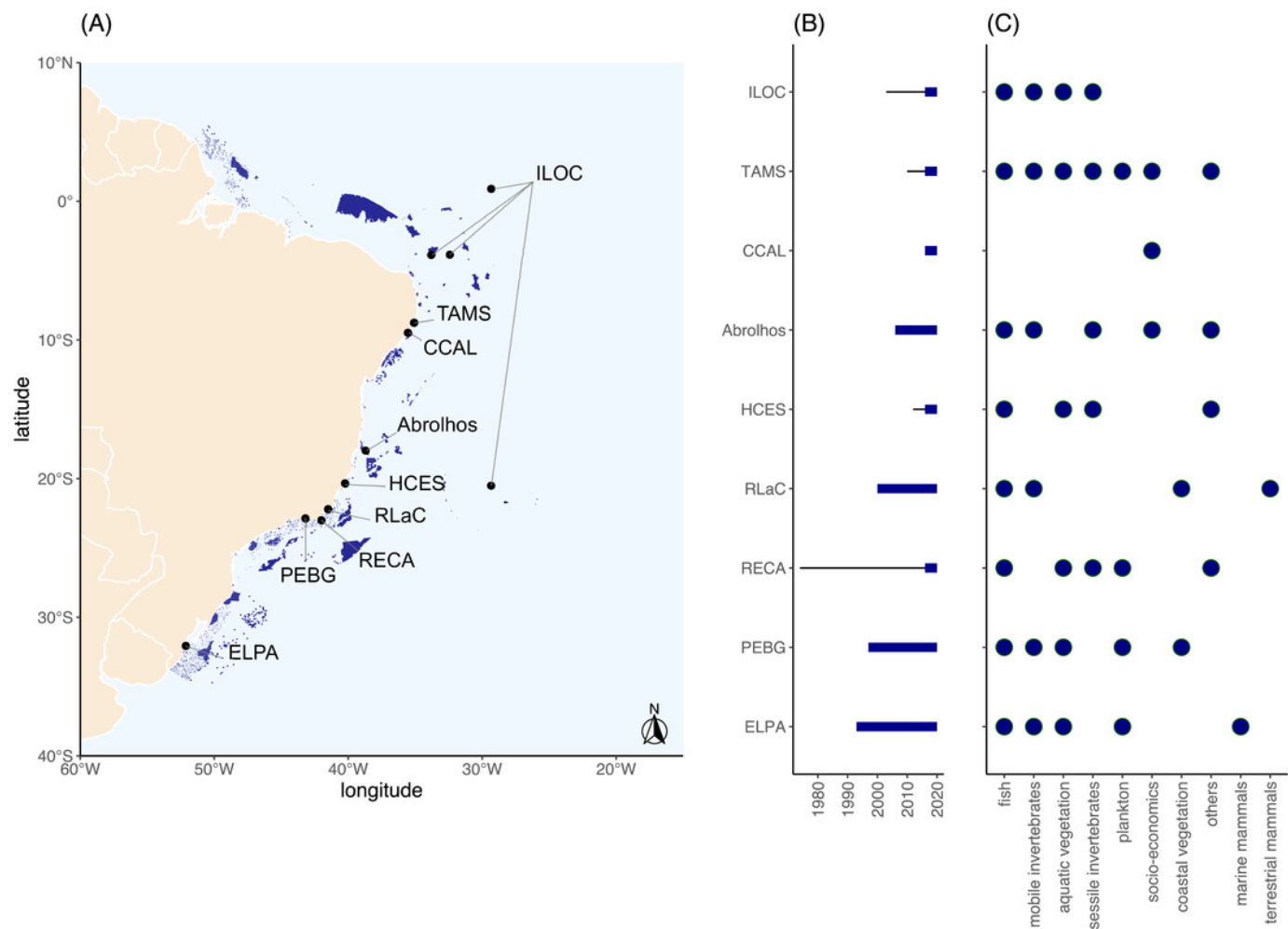
Figure 2

Relationship between scientific production and monitoring time of long-term monitoring sites (PELD) in Brazilian coastal ecosystems.

Generalized linear model (GLM) adjusted to values by using Poisson distribution and log as link function (p < 0.001, AIC = 386.7). Shaded area are 95% confidence intervals predicted by GLM. ILOC - *Monitoramento de Longa Duração das Comunidades Recifais das Ilhas Oceânicas Brasileiras*, TAMS – *Tamandaré Sustentável*, CCAL - *Costa dos Corais Alagoas*, HCES - *Habitats Costeiros do Espírito Santo*, RLaC - *Restingas e Lagoas Costeiras do norte do Estado do Rio de Janeiro*, RECA – *Ressurgência de Cabo Frio*, PEBG - *Estrutura e Funções do ecossistema da Baía de Guanabara*, ELPA – *Estuário da Lagoa do Patos e Costa Marinha Adjacente*.
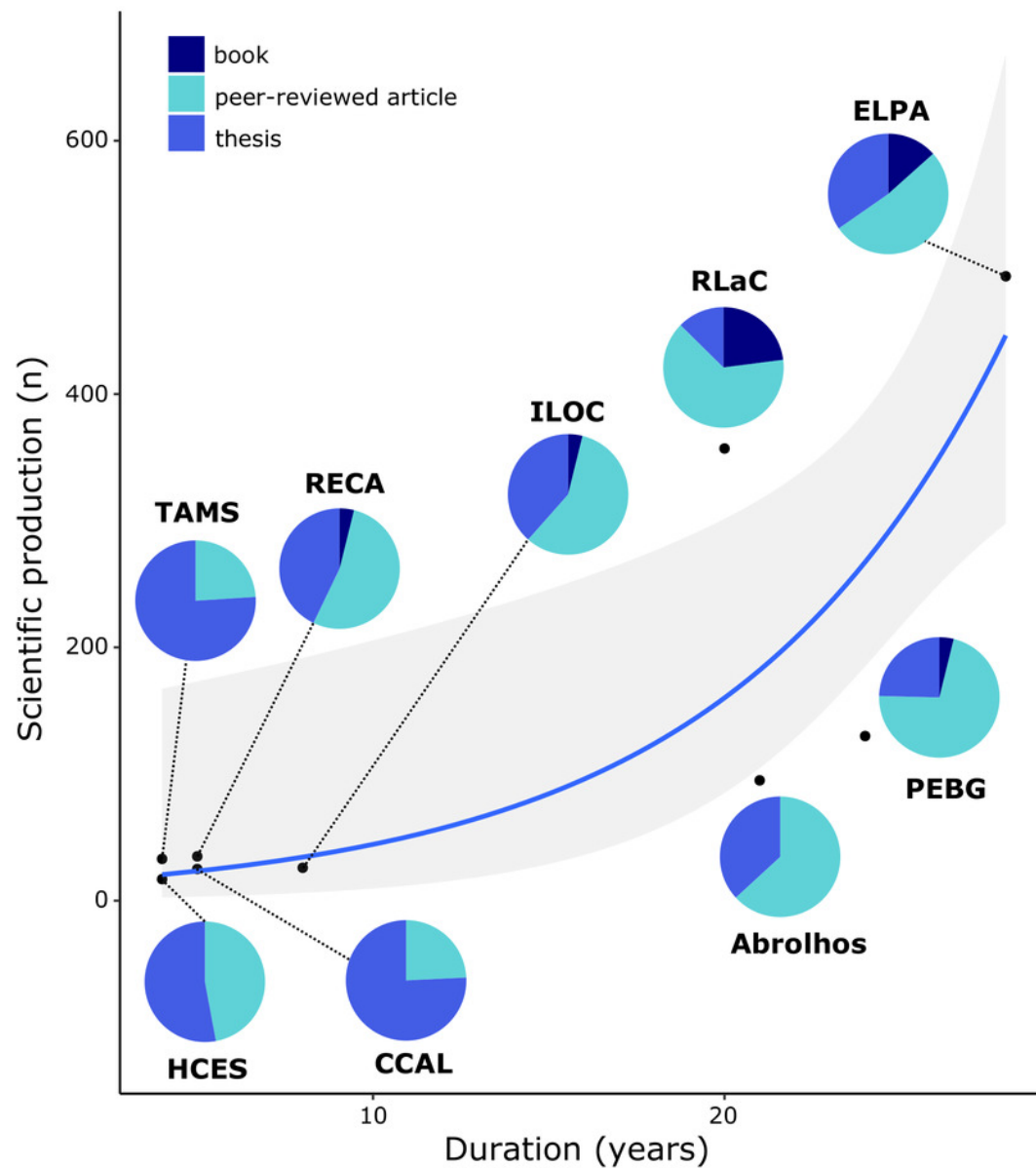
Figure 3

Accumulated funding received (A) and frequency of communication outlets used to inform results (B) of long-term monitoring projects (PELD) in Brazil.

National level funding agencies: CAPES - Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, CNPq - Conselho Nacional de Desenvolvimento Cientíûco e Tecnológico; FAPs 3 state level public funding agencies; always = 100% of time, never = 0 % of time, sometimes = ~50% of the time. ILOC - Monitoramento de Longa Duração das Comunidades Recifais das Ilhas Oceânicas Brasileiras, TAMS 3 Tamandaré Sustentável, CCAL - Costa dos Corais Alagoas, HCES - Habitats Costeiros do Espírito Santo, RLaC - Restingas e Lagoas Costeiras do norte do Estado do Rio de Janeiro, RECA 3 Ressurgência de Cabo Frio, PEBG - Estrutura e Funções do ecossistema da Baía de Guanabara, ELPA 3 Estuário da Lagoa do Patos e Costa Marinha Adjacente.
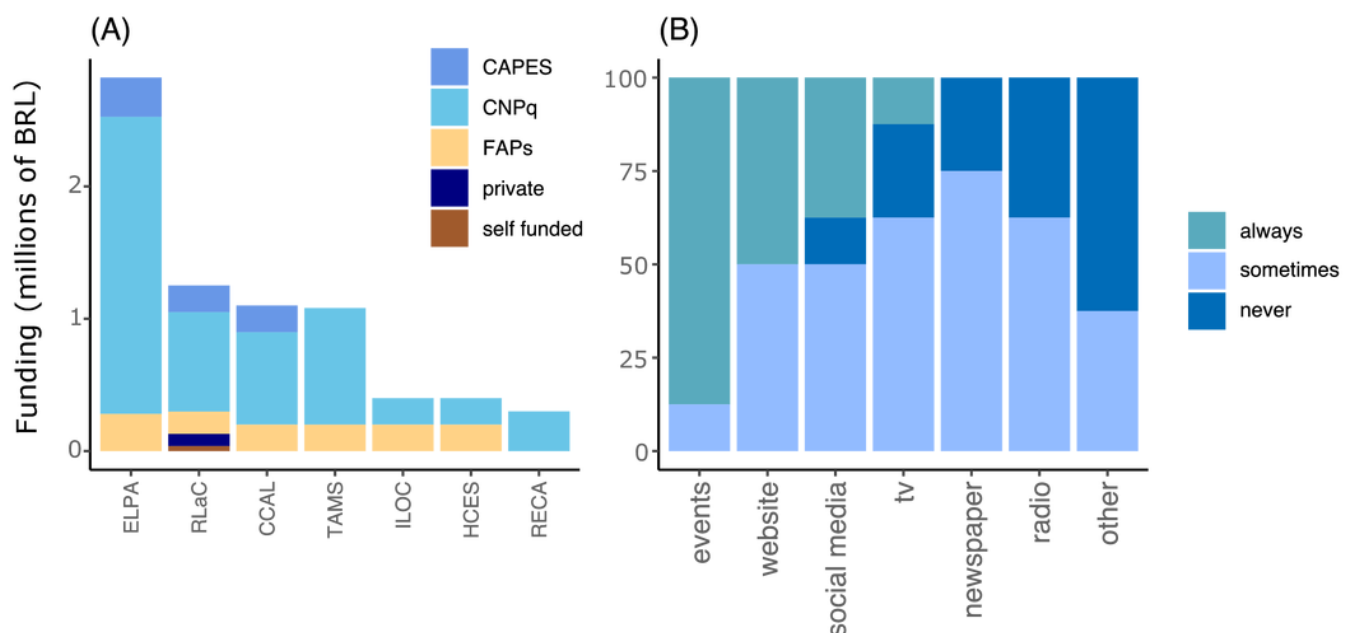
Figure 4

Network of institutions involved with marine and coastal long-term monitoring projects (PELD) in Brazil.

ILOC - *Monitoramento de Longa Duração das Comunidades Recifais das Ilhas Oceânicas Brasileiras*, TAMS – *Tamandaré Sustentável*, CCAL - *Costa dos Corais Alagoas*, HCES - *Habitats Costeiros do Espírito Santo*, RLaC - *Restingas e Lagoas Costeiras do norte do Estado do Rio de Janeiro*, RECA – *Ressurgência de Cabo Frio*, PEBG - *Estrutura e Funções do ecossistema da Baía de Guanabara*, ELPA – *Estuário da Lagoa do Patos e Costa Marinha Adjacente*. Numbers represent different partner institutions, see table 3S for details.