

7

Which monitoring strategy should be chosen?

Monitoring programs have multiple roles, and there are multiple models possible. The choice of a monitoring strategy constraint, to a large extent, the resources required maintaining it but also the insights that can be derived from the information collected. This chapter discusses the role of monitoring programmes and provides an account of the development and the nature of seagrass monitoring programs worldwide.

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Human coastal communities, which comprise almost half of the world's population, are intimately related to the marine ecosystem, which they are dependent upon for transportation, food and recreation, among many other services impinging on the quality of life of these communities. In many cases, coastal communities have been witnesses of the changes of their marine environments and how these changes affect the living resources and, in turn, their economies.

Volunteer monitoring programs increase awareness of the threats to the sustainability of coastal ecosystems and help citizens understand environmental problems and issues, and become involved in solving them. An important goal of any ecological monitoring program is, therefore, to educate and reach out to society by involving society in the observation of changes in the ecosystems. Volunteer-based seagrass monitoring programmes are, therefore, instrumental vehicles to increase awareness of the important role of seagrasses in the ecosystem, the threats these ecosystems are exposed to, and the importance to preserve the seagrass meadows to maintain the biological balance and the biodiversity of the coastal ecosystem. Seagrass monitoring programmes create a culture for the community's support of the protection and wise management of coastal habitats. Those involved develop a deep sense of the need for protection of their local marine environments that expands throughout the wider community. This social role is at least as important as the information these programs

delivered on the status and trends of the ecosystems observed.

Overview of existing monitoring programs

Awareness of the need to monitor the health status of seagrass beds has rapidly grown over the past two decades (Fig. 7.1). This growing interest has developed in with a greater knowledge of the role seagrass meadows play in coastal ecosystems. Rapid development, involving multiple changes in land use and use practices, urban development, shoreline development, and intensified fisheries and aquaculture has radically altered the inputs or materials and pressures on coastal ecosystems. Seagrass meadows, along with other sensitive coastal ecosystems, have experienced widespread decline at a rate of about 2 % year⁻¹, worldwide. Seagrass monitoring programmes were initiated to address these losses and provide information on the trends and status of seagrass meadows.

The first seagrass monitoring programmes started at the beginning of the 1980's in Australia, USA and France. In the 1990's seagrass monitoring programmes have experienced an important increase (Fig. 7.1).

At the moment more than 40 countries have developed seagrass monitoring programmes in more than 2000 meadows around the world. These monitoring programmes target 31 seagrass species around the world, most of them in

Australia where all the seagrass genera are present. Many of these programs are transnational in nature, such as:

- Cooperative Monitoring in the Baltic Marine Environment (COMBINE). Started in 1992 and includes 9 European countries.
- The Caribbean Coastal Marine Productivity Program (CARICOMP). Initiated in 1990 and including 29 institutions in 22 Caribbean countries.
- Seagrass-Watch. Started in 1999, including groups in Australia and 8 Western-Pacific countries.
- SeagrassNet. Started in 2001, including groups in Australia, USA and 11 Western-Pacific countries.

At the national level, the more extensive network is that provided by the National Estuary Program (NEP, USA). It was started in 1984 and includes all USA coastal states, 9 of which have seagrass monitoring programs.

Information on existing monitoring programs, including protocols, results, and contacts are available through multiple web pages (Table 7.1). Many of them have an open membership, such that new programs can be linked with them (e.g. SeagrassNet), thereby contributing to a wider network.

The structure and goals of monitoring programs are diverse, as some of them are conducted exclusively by scientists or technical personnel, and others, such as Seagrass-Watch, rely on volunteers. In addition, the number and nature of properties monitored also differ among them. Those based on scientific and/or technical personnel typically include a broader array of properties, some of them involving complex techniques and equipment, while other monitoring programmes measure less parameters, but across much larger areas. Only a few monitoring programs are exhaustive in detail and, at the same time, encompass broad areas, as these require vast resources. Volunteer-based networks offer added values, such as community outreach and awareness, but they require a clear leadership to be viable and sustainable over time. Experience shows that a leader with appropriate technical or scientific credentials, as well as social skills, is needed to drive and maintain the momentum of volunteer-based programs. In addition, volunteers must be motivated through the prompt delivery of results and diagnostics on the seagrass meadows monitored, as well as through activities that encourage communication

and sharing of experience among the volunteer network. Web pages are useful tools to address both these actions and should be, therefore, central components of monitoring programs. Indeed, most of them do have web pages to serve these purposes (Table 7.1).

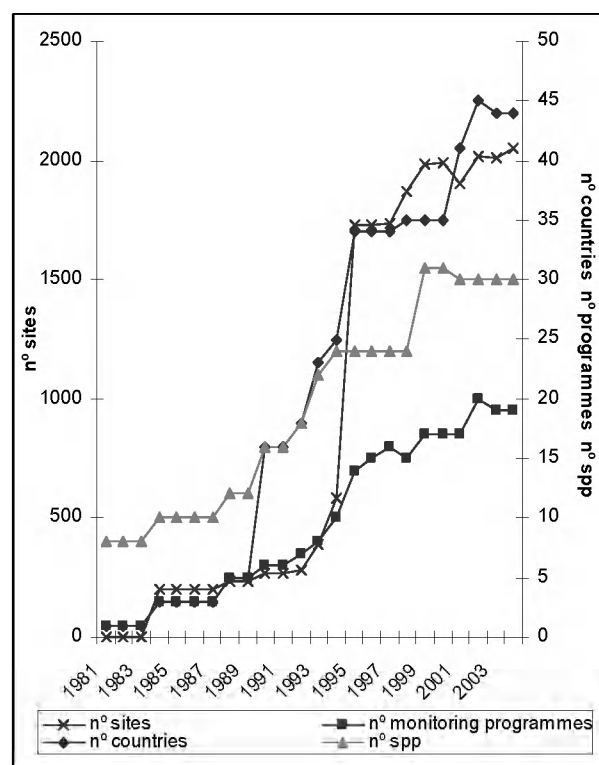


Figure 7.1. Evolution of seagrass monitoring programmes in the last two decades.

The most widely used parameters in seagrass monitoring programmes are the cover and density of seagrass meadows, as to ascertain their abundance and detect changes. The capacity to detect decline depends on the inherent uncertainty of these estimates, which can be substantial, such that only relatively abrupt changes (> 20%) can be unambiguously resolved. Direct observations of the distribution of the meadows along transects are used in many of the monitoring programmes. This method is effective in detecting declines, however, is a rather time consume procedure certainly if large areas are to be covered. For this reason, direct observations along the distributional range of large seagrass meadows become impractical. In such instances, remote sensing (optical, such as satellite or airborne remote photography; or acoustic, such as side scan sonar) is an alternative used in many of the monitoring programmes. Programs that assess changes across the entire meadows are far more effective in detecting trends than

Table 10.1 WEB-sites of existing monitoring programs

Name	WEB-site
Posidonia oceanica Monitoring Network in Balearic Islands (SPAIN)	http://lifeposidonia.caib.es
Posidonia oceanica Monitoring Network in Cataluña (SPAIN)	http://www.gencat.net/darp/faneroga.htm
Posidonia oceanica Monitoring Network in Comunidad Valenciana	http://www.ecologialitoral.com/volunt.htm
Posidonia Monitoring Network in the NW Mediterranean sea. GIS-Posidonie (FRANCE)	http://www.com.univ-mrs.fr/gisposi/
Danish National Monitoring and Assessment programme (DENMARK)	http://www.dmu.dk/forside_en.asp
Estonian Environmental Monitoring Programme-COMBINE (ESTONIA)	http://www.seiremonitor.ee/tekstid/rkp_ing/?leht=general
Cooperative Monitoring in the Baltic Marine Environment (COMBINE)	http://www.helcom.fi/Monas/CombineManual2/PartA/Introduction.htm
The Caribbean Coastal Marine Productivity Program (CARICOMP)	http://www.ccdc.org.jm/caricomp.html
Ecosystem Health Monitoring Program (Moreton Bay-AUSTRALIA)	http://www.coastal.crc.org.au/ehmp/index.html
Environment Bay of Plenty (NEW ZEALAND)	http://www.boprc.govt.nz
Environment Waikato (NEW ZEALAND)	http://www.ew.govt.nz
Seagrass Watch	http://www.reef.crc.org.au/aboutreef/coastal/seagrasswatch.html http://www.users.bigpond.com/wildlifebb/projects/seagrass/default.html http://www.dpi.qld.gov.au/home/default.html http://www.bayconnect.com.au/seagrass/default.htm http://www.ouchvolunteers.org/
SeagrassNet	http://www.seagrassnet.org/ http://www.worldseagrass.org/
North River Monitoring Program (N.Carolina-USA)	http://www.marine.unc.edu/Paerllab/research/seagrass/index.html
Florida Key National Marine Sanctuary Monitoring Program (Florida-USA)	http://www.serc.fiu.edu/seagrass/
Barneget Bay Estuary Program (New Jersey-USA)	http://www.bbep.org/
Buzzards Bay Estuary Program (Massachusetts-USA)	http://www.buzzardsbay.org/
Charlotte Harbor National Estuary Program (Florida-USA)	http://www.dep.state.fl.us/coastal/activities/research/seagrass.htm http://www.charlotteharbornep.com/
Indian River Lagoon Monitoring Program (Florida-USA)	http://www.irl.sjrwmd.com http://www.sjr.state.fl.us
Long Island Sound Study (New York/Connecticut-USA)	http://www.longislandsoundstudy.net
Chesapeake Bay Monitoring Program (Maryland-USA)	http://www.chesapeakebay.net/index.cfm http://www.mdcoastalbays.org
Narragansett Bay Estuary Program (Massachusetts-USA)	http://www.nbep.org/
New Hampshire Estuaries Project (New Hampshire-USA)	http://www.state.nh.us/nhep
New York/New Jersey Harbor Estuary Program (New York/New Jersey-USA)	http://www.harborestuary.org
Peconic Estuary Program (New York-USA)	http://www.savethepeconicbays.org http://www.co.suffolk.ny.us/webtemp3.cfm?dept=6&id=980
Puget Sound Estuary Program (Washington-USA)	http://www.psae.wa.gov
Tampa Bay Estuary Program (Florida-USA)	http://www.tbep.org/
Tillamook Bay National Estuary Project (Oregon-USA)	http://www.co.tillamook.or.us/gov/estuary/tbnepe/nephome.html

quadrat-based programs, which can only provide inferences on very local scales.

The health of seagrass meadows is intimately linked to the health of the wider marine environment. For this reason many programmes,

especially in USA, combine seagrass monitoring with the monitoring of water, and sometimes, sediment quality. Indeed, information on the environmental quality can help ascertain the causes of trends detected on seagrass meadows, thereby facilitating action, and, in turn, trends in seagrass health can act as alarm indicators of trends in the environment. Among the environmental properties monitored, water transparency, measured with the Secchi disc, provides the most integrative, robust and yet simple indication of water quality.

Seagrass meadows are presently legally protected in many countries, including also obligations to restore lost or deteriorated meadows. In fact legal frameworks in place in some countries establish a zero-loss policy legislation, requiring that the lost area be replaced by habitat with equivalent functional values.

The selection between different monitoring options is dependent on the structure and resources available: e.g. cumbersome methods are not practical for volunteer-based monitoring networks. The choice between protocols depends on the species monitored. For instance, shoot counts are not practical to monitor in *Zostera noltii*

meadows, where small shoots occur at great densities (several thousand per m²), and cover and density estimates are highly seasonal for most seagrass species, except for *Posidonia oceanica*, which shows very little seasonal change in shoot density, and where abrupt declines in shoot densities are, therefore, clear indication of decline. The monitoring of the upper and deep depth limits of the meadows deliver robust indications of overall status for all species, as these are easily detectable and occur where stresses are most likely: water quality affecting the deep limit and erosion or burial affecting the shallow limit. However, the monitoring of the depth limit of *Posidonia oceanica*, which reaches deepest (45 m in the clearest Mediterranean waters) among the European seagrasses, is cumbersome and requires professional diving.

Hence, the design of a new monitoring program must consider the resources available, and also the adequacy of different methods for the various species, which requires knowledge on their growth rates and basic ecology, as provided in the first half of this handbook.