Sandy Beach Biodiversity Survey Protocol
Pole to Pole Marine Biodiversity Observation Network of the Americas

Protocol developed during the Marine Biodiversity Workshop: from the Sea to the Cloud
Date: Sep-12-2018

Note:
This protocol is a first attempt to develop biodiversity indicators on sandy beaches from Pole to Pole (Patagonia to the Arctic). This protocol was written and discussed with the sandy beach workgroup including: Eleonora Celentano, Daniela Yepes Gaurisas, Yasmina Shah Esmaeili, Guilherme Corte, Carlos Barboza, Maikon Di Domenico, and revised by experts on sandy beach ecology.

1- Main Question/Rationality of the monitoring

Develop a biodiversity indicator for sandy beaches, easy to monitor and efficient in detecting changes with a long-term commitment among the countries

Scientific questions that could be addressed

What are the biodiversity (richness, abundance, functional traits) changes in sandy beaches related to extreme events, wave climate, temperature, and/or primary production?

What are the changes in functional biodiversity (i.e., detritivores, predators, suspension-feeders) related to the energy that beaches experience?

What is the effect of climate change on the niche availability/selection of macrofauna species?

Indicators

Definition of Indicator (adapted from SINAC, 2016)
Characteristic or condition that is relevant, precise and sensitive to changes over time and that can be determined and characterized in an accurate and practical way with reasonable cost.

Monitoring
Measurement of an indicator applied over time to evaluate the changes in the environment.

Permissible variation
The minimum biodiversity measure in which each sandy beach that can persist both in time and space.

Biodiversity measurements
Macrofauna composition (abundance, richness, Beta-diversity, functional traits)

Seascape measurements

Beach slope, granulometry, sediment temperature, beach orientation, the length of the distinct habitats (beach width and swash width),

Data from the cloud (Satellites/Database):
Altimetry, sea level, primary production, wind, storms, cyclones, hurricanes, wave period, wave height, radiation, water temperature

2- Where and when (*adapted from SARCE*)

A location in your region is an area of maximum 100km radius and consists of maximum 3 sites that should be 5km apart. Within that location, at each particular site, an area for sampling should be selected. Selection should be based on the information below.

Preferable beach state/characteristics
For sandy beaches: the site must be an oceanic, exposed, dissipative beach (Dean parameter (Ω) > 5, Brown & McLachlan 2005) with normal circulation (avoiding embayed/closed beaches), at least 200 meters away from any freshwater output, and a primary dune should be present.

- Remember that we want to cover as much area as we can; please select your sites trying to get the best geographic spread.
- Avoid developing this protocol in estuarine/ wave protected sites

Warning: These types of (dissipative) beaches are not present everywhere. Therefore, please make sure the beach you select is exposed and oceanic, and as dissipative as possible. In any case, before the monitoring process starts, all the selected beaches should be evaluated by the researchers interested applying the pole to pole protocol.

Daily conditions
Morning – low spring tide (below 0.2 meters)

Periodicity
The sampling should occur minimum biannually, preferably seasonally (four sampling), depending on resources.
Warning: Considering the logistical and time capabilities of each one of us, we must define biannually, the minimum sufficient periodicity to be comparable for the Pole to Pole. There is no financing for carrying out the sampling.

Once at the site, take note of the exact geographical location and fill the general data in the field sheet (attached) (*adapted from SARCE*)

Table 01. - General characteristics of your sampling site.

Descriptor	**Definition**	**Outcomes**
Location	Name of a given location (City, Beach, Neighborhood)	It will be unique for this data sheet
Site	Name of a given site	Could be more than one

Urban Area	Located within a radius of 10 kilometers of a human settlement of more than 5000 habitants	Yes/No
MPA	Marine Protected Area	Yes/No
Distance to rivers	Can be done a posteriori using GIS	Distance value in Km
Dunes	Sand that lies behind the part of the beach affected by tides. They are formed over many years when windblown sand is trapped by beach grass or other stationary objects.	Across-shore distance from dune to the swash value in meters. Additionally the dune area (square meters) can be measure by satteletty images, when available.
Slope	As measured with the "Emery method" a scheme of this basic device will be sent shortly.	Degrees. Will be measured in one transect
Grain Size	(or particle size) is the diameter of individual grains of sediment.	phi or millimeter, will be measured in three level in one transect. Classes named as Wentworth (1922)
Wave height	(Hb) wave height at breaking. The wave height is the vertical difference between a wave crest and a wave trough	Meters. Will be measured in situ or oceanographic buoys (wave sensor)
Wave period	The time interval between two consecutive wave crests	Seconds. Time required for successive crests to pass a fixed point. The measurement of 11 successive crests in a fixed point defined *a priori*.

3- Sampling strategies

Macrofauna sampling strategy (*adapted from ReBentos*):

Systematic transect-sampling (Figure 1):

Three linear transects, spaced more than 3 meters and less than 10 meters apart. The distance of the upper limit of the transects on each site should be determined from a fixed reference point. Sampling in six regular points along the transects – divide the total length of the intertidal in 6. Start immediately below the high tide level, usually below the drift line, to the lower level of the swash. (one in the water/swash zone) (n=18). A distance between sampling points should be kept around 4m, but more can be taken if the intertidal area is very large. The distance between points should be recorded.

Sampler:
Corer from 15 centimeters in diameter reaching up to 25 centimeters in the sediment.
Sieve mesh size = 0.5 millimeters. When the corer is located in the drift line a mesh sieve to cover the corer should be used. Several talitrids live associated with the wracks and can jump quickly out of the corer.
Warning: Be aware when the abundance of individuals is low in your site. The minimum area sampled at each across-shore level at a sampling station should approximate 0.3 m^2 (*see Schlacher et al. 2008*). Our sampling strategy with 18 units will make up 0.32 m^2 with 15-cm diameter corers. Consider to increase your sampling effort, e.g. number of transects, levels, or increase your area to 0.57 m^2 with 20-cm diameter corers, or 0.88 m^2 with 25-cm diameter corers, if you want to answer other ecological questions beyond the pole-to-pole aims.

If a research facility is located close to your site, the samples should be transported in plastic bags to guarantee the washing process occurs without losses. If not, there is the possibility to wash samples in the field (with caution, since in general the size of the animals makes this a delicate process). Where the sediment particles are coarser than 0.5 millimeters and heavier than the animals, decantation or elutriation techniques may be used. In both methods, it is recommended to repeat at least 5x the processing for each sample and to verify if any animal remained in the sediment after the processing. Overall, depending on sampling, the sediment size, the amount of sediment, and the taxonomical aim, is necessary the narcotization of the animals (e.g., magnesium chloride) to extracting them from the sediment (*see Eleftheriou, 2013*).

Please try to identify the organisms the best you can, preferably to species level. Samples must have to be collected for later identification in laboratory conditions. This working group has various taxonomists, who can help with identifications (*adapted from the SARCE*).

Methods of preservation:
Try to identify the individuals alive when possible and photograph them, then use ethanol as a fixative (useful for molecular studies), otherwise they can be fixed in buffered formol 4%. Specific fixatives may also depend on the technique and the taxon. For this protocol, we also recommend using magnesium chloride technique before fixation for morphological studies or microphotographs (*see Eleftheriou, 2013*). If you have a microscope with camera available, try to take a picture of each species to add to the database.

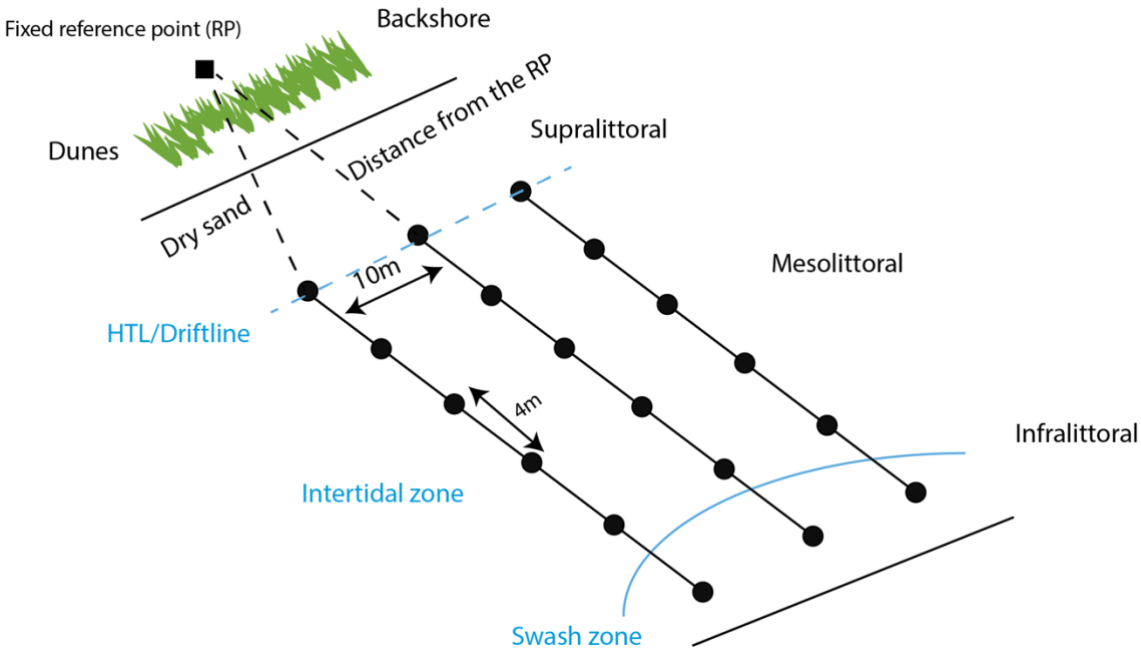

Figure 1. *Systematic transect-sampling strategy*

Environmental measures:
Slope should be measured in one transect for each site. Sediment temperature and sediment samples for the calculation of mean grain size, sorting, and skewness, should be taken. Three per sampling time per site, one supralittoral, one mesolittoral, one in the swash zone.

ONCE THE SAMPLING IS DONE (*adapted from the SARCE*)

- Upload the data in excel files that will be provided (not ready yet)
- You will add extra information to the data that you collected regarding the characteristics of the species that you encountered in your sampling sites.

You will have to indicate:

1) what feeding group (separated in groups: primary producers, herbivores, suspension-feeders, carnivores, detritivores, omnivores, scavengers) does a particular species belong to
2) whether a particular species is invasive, introduced or not
3) include the distance from the urbanization to the base of the beach dune (measure of urban effect)
4) try to include information of databases or satellite images: Chlorophyll a, phosphate, nutrients, and distance from river mouth, pollution, SST, photoperiod and tidal regimes.

4- Definitions:

Dissipative beach (from McLachlan & Brown, 2006, see new version McLachlan & Defeo, 2018): A dissipative beach is flat and maximally eroded, and the sediment is stored in a broad surf zone that may have multiple bars (sandbanks) parallel to the beach. Waves tend to be

spilling and break a long way from the beach, often reforming and breaking again. In this way, most wave energy is consumed in the surf zone before reaching the beach. Swash along the shoreline may be gentle, although there are usually pronounced infragravity waves. Landward water flow occurs as surface bores, while return flow is mainly in the form of bed return flow (although some widely spaced rip currents may occur). Wave energy is thus dissipated in the surf zone rather than reflected from the beach face.

Swash zone (from Nielsen, 1999): The swash zone forms the land-ocean boundary at the landward edge of the surf zone, where waves runup the beach face. It is perhaps the region of the ocean most actively used by recreational beach users and, being very visible, is the region of the littoral zone most associated with beach erosion and the impacts of climate change. In terms of coastal processes and coastal protection, a large part of the littoral sediment transport occurs in the swash zone, both cross-shore and longshore, which influences beach morphology, and beach erosion and beach recovery during and after storms. Wave runup is an important factor in the design of coastal protection and also generates hazards for beach users, and is the dominant process leading to the erosion of coastal dunes. Swash hydrodynamics also influence the ecology of the intertidal zone and groundwater levels in sub-aerial littoral beaches and low lying islands, which is often critical for freshwater water supply on islands and atolls

Transect (adapted from Schlacher et al., 2008): In sandy-beach ecology, transects are shore-normal lines of samples that usually run from a point at least as high as the drift line downshore to a point near the low-water mark or lower. Along each transect, samples (biological, environmental, or both) are taken at several systematically arranged levels of the intertidal slope.

Sampling site (adapted from Schlacher et al., 2008): In sandy-beach ecology, a sampling site is a short (no more than a few meters wide), along-shore stretch of beach from which samples are drawn with the express aim of describing features of that stretch of beach only. These samples could comprise one or more across-shore transects; alternatively, some other sampling design could be employed in an attempt to more explicitly capture information about the along and/or across-shore variability.

5- References

Eleftheriou, A. (Ed.). (2013). *Methods for the study of marine benthos*. John Wiley & Sons.

McLachlan, A., Defeo, O. (2018). *The ecology of sandy shores*. Academic Press.

Nielsen, P. (1999). Groundwater dynamics and salinity in coastal barriers. *Journal of Coastal Research*, 15, 732-740.

(ReBentos) Rosa Filho, J.S., Nascimento Corte, G., Fabricio Maria T, André Colling L, Regina Denadai M, Cruz da Rosa L, Borzone CA, Marques de Almeida TC, Rosental Zalmon I, Omena E, Veloso V, Zacagnini Amaral AC (2015) Monitoramento de longo prazo da macrofauna bentônica entremarés de praias arenosas. In: Turra, A., Denadai, M.R. (eds) Protocolos para o

monitoramento de habitats bentônicos costeiros – Rede de Monitoramento de Habitats Bentônicos Costeiros – ReBentos. Instituto Oceanográfico da Universidade de São Paulo, São Paulo, pp 194– 208

Schlacher, T. A., Schoeman, D. S., Dugan, J., Lastra, M., Jones, A., Scapini, F., McLachlan, A. (2008). Sandy beach ecosystems: key features, sampling issues, management challenges and climate change impacts. *Marine Ecology, 29*, 70-90.

SINAC. 2016. Protocolo PRONAMEC: Protocolo para el monitoreo ecológico de las playas arenosas. Proyecto Consolidación de las Áreas Marinas Protegidas. Programa de Naciones Unidas para el Desarrollo (PNUD) y El Fondo para el Medio Ambiente Mundial (GEF), San José, Costa Rica. 39p

Wentworth, C. K. (1922). A scale of grade and class terms for clastic sediments" *The Journal of Geology*, 30 (5), 377-392.