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Shoreline Conservation Targets: case studies for the North Atlantic Coast ecoregional assessment

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General Approach for Defining Shoreline Conservation Targets
Based on NOAA ESI Data

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Introduction

Marine conservation planning teams in California, the Pacific Northwest coast, and the North Atlantic coast are working together to develop a consistent approach for identifying shoreline conservation targets for use in ecoregional planning. This document provides general guidance on developing shoreline targets in a nested hierarchical approach that would allow for rollup of general targets over multiple regions, yet still allow for regional specificity in classifying targets. The approach utilizes the NOAA Environmental Sensitivity Index (ESI) database and builds on the ESI classification scheme (NOAA 1997). ESI was designed for ranking sensitivity of shoreline types to oil spills and is the best and most accurate coast-wide database for shoreline types; however, the classification scheme does not necessarily meet biodiversity conservation planning needs. The British Columbia ShoreZone classification (Howes 1994) is based on substrate and sediment type, slope and width and identifies approximately 34 shoreline types. The recommended approach described below builds first on a distinction between rock, rock and sediment, sediment, and anthropogenic substrates that provide a foundation for other descriptors used to identify general shoreline types.

Guidelines for Classifying Shoreline Types

The following are recommended guidelines for cross-walking NOAA-ESI shoreline data to a consistent classification of shoreline conservation targets for the Pacific west coast. Note that there are other regions where ESI data has been assembled; these other geographic areas may have entirely different environmental characteristics and therefore these guidelines may need to be revised to accommodate for them. Nevertheless, these recommendations aim to (1) promote consistent approach for identifying and naming shoreline types along the Pacific west coast south of Alaska, (2) provide guidance on how to resolve multiple ESI types at a single location, and 3) develop working definitions of shoreline types.

We developed a general approach to building a Pacific west coast shoreline classification that is based on a crosswalk of the ESI types to a subset of regionally important natural shoreline types based on substrate or landform and sediment types (Table 1). The two man-made shoreline types in ESI, seawall and riprap, would be retained as shoreline types but included as "cost factors" rather than conservation targets in the planning process.

Table 1: General shoreline categories (without exposure modifier)

Substrate Type	Sediment Type	General Shoreline Types (may vary somewhat regionally)
Rock[1]	N/A	Rock platform
	N/A	Rocky cliff
	N/A	Rocky shore
Rock & Sediment [2]	Gravel	Rock platform/shore/cliff with gravel beach
	Sand	Rock platform/shore/cliff with sand beach
Sediment[3,4]	Gravel	Gravel beach
	Sand & Gravel	Mixed sand and gravel beach
	Sand	Coarse-grained sand beach
	Sand	Fine-grained sand beach
	Sand/Mud	Tidal flat (mudflat or sandflat, if known)
	Sand/Mud	Marsh/Tidal Flat
	Mud	Marsh (brackish or saltmarsh, if known)
Anthro-pogenic	N/A	Seawall
	N/A	Riprap

Notes:
1. Rock: ESI does not distinguish slightly inclined or steep slopes for the bedrock landforms that do not contain sediment; if appropriate, combine "rocky shores" and "rock cliff" to form "rocky shores/cliffs."

2. Rock & Sediment: A combination of hard and soft substrate types forms the basis of many ESI types. For example, while both ESI and the BC systems recognize the (wave cut) rock platform type, in many cases the ESI type is found in combination with sand or gravel. Since the presence of sediment grains in combination with bedrock may result in a scoured rocky substrate, it may be important to retain the grain characteristics where they occur either above or below the rock platform and rocky shores. For example, a location with sand beach above or below a rock platform would be called "rock platform with sand beach," or “rock with sand beach”. For these cases, rocky platform, shore or cliff can be classed separately or lumped into “rock” with gravel or sand beach.

3. Grain size plays an important role in structuring beach communities and in use of beaches by shorebirds and other elements of biodiversity. At least 3 categories
of grain-size should be used, if possible, when classifying beach types (gravel, sand and gravel, and sand); further subdividing sand beaches into fine and coarse grained beaches is also recommended.

4.Marsh or Tidal Flat types: To preserve important information, marsh types can be split out into “brackish” or “saltmarsh”, if known; similarly tidal flats can be specified as “mudflat” or “sandflat”, if known. In many locations, both marsh and tidal flat are present in the same locations and “marsh/tidal flat” should be considered a separate target.

Assessments should include brief definitions of the general shoreline types that were used. Some examples are provided below, modified from Berry et al. 2001:

- ROCK PLATFORM: Horizontal or near horizontal rocky intertidal areas, with no organized beach features. Most commonly associated with rock outcrops.
- ROCKY SHORES/CLIFFS: Shallow or steeply sloped rocky shores or vertical rocky cliffs, with no organized beach features.
- ROCK PLATFORM w/ SAND BEACH (or ROCK w/ SAND BEACH): Rock platform, but with associated fine-medium-or-coarse grained sand beach either landward or seaward in the intertidal.
- ROCK PLATFORM w/ GRAVEL BEACH (or ROCK w/ GRAVEL BEACH): Rock platform, but with associated gravel or sand/gravel beach either landward or seaward in the intertidal.
- ROCKY SHORE/CLIFF w/ SAND BEACH (or ROCK w/ SAND BEACH): Rocky shore/cliff, but with associated fine-medium-or-coarse grained sand beach either landward or seaward in the intertidal.
- ROCKY SHORE/CLIFF w/ GRAVEL BEACH (or ROCK w/ GRAVEL BEACH): Rocky shore/cliff, but with associated gravel or sand/gravel beach either landward or seaward in the intertidal.
- GRAVEL BEACH: Sediments comprised of boulder, cobble, and/or a pebble mixture with <10% sand content. Gravel beaches are steeper in the lower intertidal zone; middle to high intertidal zones are commonly armored.
- SAND and GRAVEL BEACH: Sediments are a mixture of boulders, cobbles, pebbles, and sand (with >10% sand and >10% gravel). Middle to high intertidal is commonly armored with sand in the subsurface.
- SAND BEACH: Sediments <10% gravel and >50% sand; sediments are highly mobile.
- TIDAL FLAT (SAND, SAND & GRAVEL, OR MUD): Slopes are low, <5-20 degrees with the berm the steepest part of the intertidal zone. May be composed of sand (<10% gravel and >50% sand) or mud (<10% gravel and > 50% mud).
- MARSH: Includes both brackish and salt marsh habitats; vegetation type depends in large part on freshwater input to the estuary. Sediments of variable texture but commonly mud and organics; typically low wave exposure environments.

Wave Energy or Exposure

Exposure is a very important factor structuring shoreline systems. There are generally two approaches to including exposure classifications in shoreline targets that should be evaluated before developing regional shoreline classes. First, the ESI classification scheme includes exposure modifiers (“exposed” or “sheltered”) on many shoreline types. For example, some rocky shores are classified as “exposed” or “sheltered”; however, in some cases not all rocky shore lengths are classified, so the user has to identify a default classification. It is important to read the underlying ESI descriptions to better understand the appropriate use of these exposure modifiers in the classification scheme. For California, the ESI exposure modifiers for rocky shores and tidal flats were considered sufficient to add to the classification scheme for some targets (rocky shores/cliffs/platforms and tidal flats). In the Pacific Northwest, however, planning teams decided that the ESI wave energy modifiers should be removed and a calculated fetch be added to the general shoreline types.

7There are various fetch models available to calculate exposure, as well as different methods for classifying the results. For the Pacific Northwest coast, we chose to use a model developed by LTL Limited (Victoria, British Columbia, Canada) and classify fetch results into four exposure classes. These classes include "very exposed," "exposed," "protected," and "very protected." The maximum and effective fetch calculations are classified using Morris (2001). Two additional exposure classes, "semi exposed" and "semi protected," can be added depending on the desired number of total targets for the ecoregion. For the Pacific Northwest region we aggregated the "exposed" class into "semi exposed," and the "protected" class into "semi protected." We propose the same approach for the North Atlantic Coast ecorgion. The exposure classes defined by the fetch model should be added to the shoreline types after the ESI crosswalk (e.g., exposed rocky shore/cliff). The exposure and shoreline combinations should be evaluated to remove any implausible combinations (e.g., very exposed marsh).

We have been calculating fetch for ESI regions in the North Atlantic ecoregion (Figure 1). Where ESI does not exist, for instance in the state of Maine and in Canada, we have been utilizing other data sets (e.g., coastal geology, species distributions) along with fetch to determine general beach types. These will be merged with the ESI region data in order to develop an ecoregion-wide shoreline ecosystem delineation.

Nearshore bathymetry and prevailing winds are important factors to consider when refining output from the fetch model. The fetch model calculates the amount of water mass in front of each shoreline segment regardless of nearshore water depth or wind direction. Therefore output from the fetch model may indicate an exposed bay from the perspective of water energy hitting beach, but if the water is very shallow then the amount of energy may be less of a factor than local bathymetry and slope. Other characteristics to consider include coastal topography and regional variation (e.g., fjord systems surrounded by high relief and glaciers).

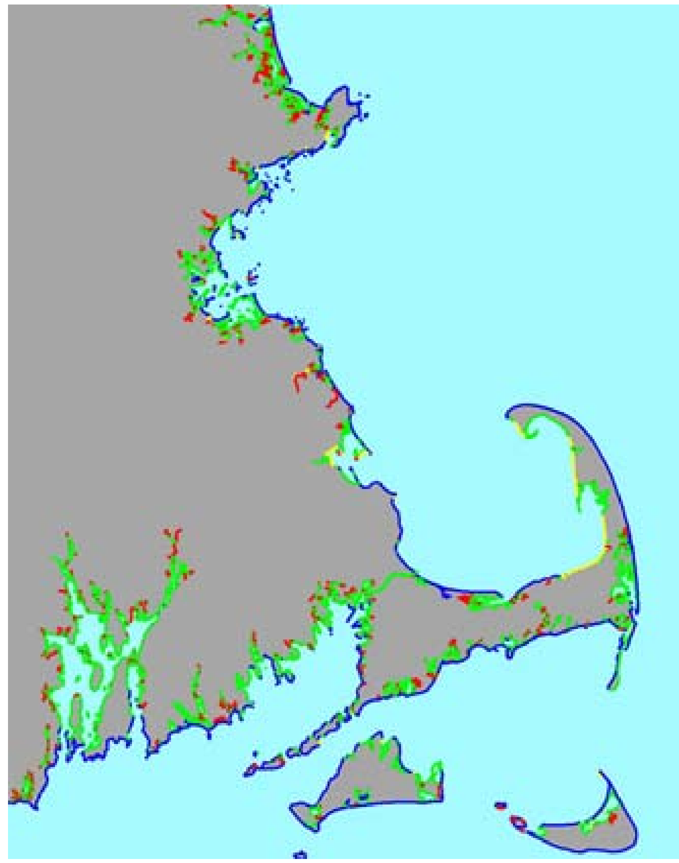

Figure 1: Fetch or wave energy output for Massachusetts and Rhode Island shorelines. Blue shorelines are very exposed; yellow shorelines are exposed to semi-exposed; green shorelines are semi-protected; red shorelines are protected to very protected.

Combinations of ESI types

Often the ESI database identifies several shoreline types present at the same location as combinations, described from landward to seaward in orientation. It is well recognized that many errors exist in depicting unique ESI combinations of multiple types. Therefore we decided that it is important to aggregate these unique combinations into a reasonable number. Rather than favoring the seaward or landward type, we recommend evaluating two alternate approaches for crosswalking ESI data to a general set of shoreline targets for the assessment: (1) identify which types or important combinations of types are rarest or of highest biodiversity importance and use a set of decision rules to identify a single type (or combination) at each location, or (2) retain all the major shoreline types present at that location as potential targets (collapse them to the regional conservation targets) and identify primary and secondary targets at each location.

These two approaches are discussed below:

(***1) Use Decision Rules to Identify Shoreline Type***: For the Northern California assessment, decision rules for identifying the most important shoreline component at each location were based on biodiversity value and rarity of shoreline types. Marshes and tidal flats are two systems in California that have been the most impacted by coastal development; over 90% of the coastal marshes have been lost. Of the whole Northern California shoreline, 17% was classified as marsh or tidal flats, 30% as rocky shorelines, and 43% as beaches; sheltered rocky shores were the rarest type in the region. As an example, the general decision rules applied to the classification included:

- Marsh and tidal flats took precedence over rocky shores which took precedence over beach types; however sheltered rocky shores took precedence even over marsh and tidal flats due to their rarity (e.g., Sheltered rocky shores > marsh /tidal flat > rocky > beaches)
- When marsh and tidal flats co-occurred, they were both retained in a "tidal flat / marsh" category
- Rocky cliffs took precedence over rocky platforms when they co-occurred as they were less common
- For beach types, the order of precedence for co-occurring types was: fine-medium grained > coarse > mixed > gravel, since fine-grained beaches tend to have associated communities that are more biodiverse
- Very rare combinations that were found in very few places were collapsed to the single rarer type (e.g., "exposed rocky cliff / beach" in California was collapsed to "exposed rock cliff")

(2) Retain Some Combinations and Identify Two Shoreline Types at One Location: Although most ESI types can be aggregated into a single shoreline conservation target, a few combinations are better left separate. This approach applied to the Northwest Coast ecoregion. One example of this is "exposed rocky shore, coarse-grained sand beach, sheltered tidal flat." It was decided that "tidal flat" be preserved as one type, and that a second type, " rocky shore/cliff with sand beach," also be preserved. This exercise still produced one set of conservation targets, though there were places where two shoreline targets existed at the same location. The more ecologically valuable target was identified first, with the identification of a second target giving more emphasis to that location in the site selection process.

- Marsh and tidal flats took precedence over rocky platforms and shores which took precedence over beach types; rarity was not highlighted because methods of gathering this information has produced many known errors (i.e., imagery is not taken during ESI flight surveys, but delineated directly on to USGS maps. Therefore there is no way to review imagery and calculate error).
- When marsh and tidal flats co-occurred, they were both retained in either a "marsh/sand flat" category (for exposed tidal flats) or a "marsh/mud flat" category (for sheltered tidal flats).
- Rock platforms took precedence over rocky shores when they co-occurred as they are known to be more diverse in infauna; beach types that interacted with rock platforms (e.g., gravel beaches/wave-cut platforms/tidal flats) took precedence over tidal flats because they act as a scouring agent on the platforms.
- For beach types we aggregated fine, medium and coarse-grained beaches in order to reduce the number of targets

Man-made structures

If man-made structures are present with other more natural shoreline types, use the natural shoreline type classification as the conservation target, but retain the man-made structure as a "cost factor" in the analysis. These cost factors are built into site selection algorithms as part of a suitability index which includes shoreline and adjacent land impacts, and factors associated with managed lands and waters. For example, ESI type "10A/8B" would be called "marsh" but that location would have an associated cost for the seawall or coastal structure component.

Discussion

The general approach for identifying shoreline targets should include a consideration of substrate type and sediment type first (as rollup categories that apply across multiple scales) and then identification of general shoreline targets that are relevant to regional environmental conditions. Each region may have a slightly different approach for developing shoreline targets from ESI data; however, the general shoreline types identified in Table 1 should provide a good starting point. The guidelines provided here should provide a framework for consistency, yet allow enough flexibility to meet regional planning needs.

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