

# The Washington State ShoreZone Inventory User's Manual



By Helen D. Berry, John R. Harper, Tom F. Mumford, Jr.,  
Betty E. Bookheim, Amy T. Sewell, Linda J. Tamayo

Nearshore Habitat Program  
Washington State Department of Natural Resources  
PO BOX 47014  
Olympia, WA 98504-7014  
360.902.1600

### The Washington State Shore Zone Inventory

Between 1994 and 2000, the Nearshore Habitat Program inventoried Washington's saltwater shorelines statewide. The resulting ShoreZone Inventory describes the physical and biological characteristics of intertidal and shallow subtidal areas. It can be used to better understand and manage Washington's coastal ecosystem.

This manual is designed for users of Washington ShoreZone Inventory data. The manual explains how the data set is organized, how it was developed, and how it can be used.

### The Inventory Data

The ShoreZone Inventory is available on CD-ROM for Windows and UNIX based systems. There is no fee for the data, but all users must comply with the terms of the license agreement.

The ShoreZone Inventory data consists of spatial data, tabular data, and documentation:

- **Documentation:** The *User's Manual* and *Data Dictionary* are available in .html format for online viewing and .pdf format for printing. These files are located in the *szdoc* directory on the CD-ROM. (userman.pdf, datadic.pdf)
- **Easy-to-use themes:** A series of easy-to-use themes cover the most-requested information, such as eelgrass distribution, percentage of shoreline modification, and shoreline type. These ArcView shape files are located in the *szthemes* directory on the CD-ROM.
- **The Complete Inventory:** The complete inventory data set is also provided. The complete inventory includes spatial data in ArcView shape file format and tabular files in .dbf format. These files are located in the *szinv* directory on the CD-ROM.
- **ArcView Project files:** Two ArcView projects provide easy access to the data for ArcView users. The *szthemes.apr* displays easy-to-use themes, and the *szinv.apr* displays the complete ShoreZone Inventory spatial and tabular data. To use the ArcView projects you need a Geographic Information System application, such as ESRI's ArcView.

**To use the spatial inventory information, you need Geographical Information System software.**

## **The Inventory Extent**

The inventory covers all of Washington's saltwater shorelines, from the Canadian border to the mouth of the Columbia River. It describes the geomorphic and biological resources of the intertidal and nearshore habitats. Features such as eroding cliffs, sand and gravel beaches, sandflats and wetlands are some of geomorphic forms mapped. Visible macrobiotic, such as wetland grasses, intertidal algae, and subtidal vegetation such as eelgrass or kelp, are also mapped.

## **The ShoreZone Inventory Approach**

The ShoreZone Inventory systematically characterizes shoreline morphology, substrate, wave exposure and biota. The inventory divides the shoreline into homogenous stretches called *units*. Within each *unit*, the shoreline is further divided into a series of across-shore *components*. *Units* are usually represented spatially by line segments, but can be polygons or points. Information on the *unit* and on its *components* is recorded in tables. These tables are then linked to spatial data, allowing a wide range of feature information to be illustrated on maps or analyzed numerically.

## **How Shoreline Data Were Collected**

Inventory information was collected from a helicopter during low tides. Video imagery of the shoreline was recorded, along with locational information (GPS). From the helicopter a geomorphologist and a marine ecologist recorded continuous commentary on the physical and biological features along the shoreline. Following the survey, the videotapes were taken back to the office for interpretation and classification. The geomorphologist divided the shoreline into *units* on orthophoto maps and described each *unit*. Next the marine ecologist added information on the living resources in each *unit*.

## **Background on the Shore-Zone Mapping System**

The Shore-Zone Mapping System was developed in British Columbia, where it has been used extensively. It was adapted by the Nearshore Habitat Program in Washington State to include additional features of interest, but remains compatible with the original BC system. Many people and organizations helped to produce the Washington data set, including the Washington State Department of Natural Resources, the Washington State Department of Fish and Wildlife, and the Puget Sound Water Quality Action Team.

## **Data Uses**

The inventory is useful for identifying the location of sensitive resources, for characterizing the distribution of habitats, and for identifying rare features. For example, maps of the inventory data can illustrate the distribution of eelgrass beds. Data can also be analyzed numerically to characterize abundance, such as the percentage of a shoreline that has been modified, or the relative abundance of different types of shorelines.

## Usage Guidelines

The ShoreZone Inventory is a conservative representation of the actual extent of the resources. The data were collected from a helicopter, so many small or seasonally ephemeral features were missed. We use the following rule of thumb to determine what features are included: *“Could I have seen the feature from the window of a helicopter traveling at 60 mph and 300 feet above the ground?”*

The inventory is a valuable regional data set because it surveyed thousands of miles using consistent methods during a relatively short time frame. However, it cannot replace higher resolution techniques or site-specific surveys.

**TABLE OF CONTENTS**

---

- EXECUTIVE SUMMARY** ..... i
  - The Washington State ShoreZone Inventory..... i
  - The Inventory Data ..... i
  - The Inventory Extent ..... ii
  - The ShoreZone Inventory Approach..... ii
  - How Shoreline Data Were Collected ..... ii
  - Background on the ShoreZone Mapping System ..... ii
  - Data Uses ..... ii
  - Usage Guidelines ..... iii
- TABLE OF CONTENTS** ..... iv
- LIST OF FIGURES** ..... v
- LIST OF TABLES** ..... v
- PROJECT OVERVIEW** ..... 1
  - Introduction..... 1
  - Project Purpose ..... 1
  - The ShoreZone User’s Manual ..... 1
  - History of the ShoreZone Inventory Project in Washington State ..... 2
  - Acknowledgements ..... 2
- SHOREZONE INVENTORY SYSTEM OVERVIEW**..... 4
  - Introduction..... 4
  - ShoreZone Units ..... 4
  - ShoreZone Components ..... 6
  - Biological Information..... 8
- INVENTORY METHODS**..... 9
  - Methods Summary ..... 9
    - Step 1 – Collected Aerial Field Data ..... 9
    - Step 2 – Mapped Physical Features ..... 11
    - Step 3 – Digitized Units ..... 12
    - Step 4 – Calculated Wave Exposure ..... 12
    - Step 5 – Mapped Biology ..... 12
    - Step 6 – Checked completed Data For Each Area ..... 13
    - Step 7 – Fixed Identified Shoreline Problems ..... 13
    - Step 8 – Assessed Data Content ..... 13
    - Step 9 – Combined Data and Checked For Validity and Integrity ..... 14
    - Step 10 – Finalized Data Fields and Formats ..... 14
- USAGE GUIDELINES** ..... 15
  - Summary ..... 15
  - Some Rules of Thumb Regarding Data Limitations ..... 15
  - Examples of Data Applications ..... 16
- DATA DESCRIPTION** ..... 19
  - Data Summary..... 19
  - ShoreZone Themes ..... 19
  - The Complete Washington State ShoreZone Inventory Data Set..... 20

<b>ADDITIONAL INFORMATION</b> .....	22
For More Technical Information on the ShoreZone Inventory .....	22
To Contact The Nearshore Habitat Program.....	22
<b>REFERENCES</b> .....	23

---

## List of Figures

<b>Figure 1</b>	Conceptual example of a unit in the ShoreZone Inventory .....	4
<b>Figure 2</b>	Map of three types of ShoreZone Inventory <i>Unit</i> .....	5
<b>Figure 3</b>	Diagram showing how across-shore subdivisions .....	6
<b>Figure 4</b>	Conceptual diagram of ShoreZone Inventory Data Structure.....	7
<b>Figure 5</b>	Map of Aerial video acquisition by year.....	10
<b>Figure 6</b>	Photo of geomorphologist in helicopter.....	11
<b>Figure 7</b>	Map of Eelgrass in Central Sound .....	17

---

## List of Tables

<b>Table 1</b>	Examples of Form and Material Codes .....	8
<b>Table 2</b>	Carr Inlet Shoreline Habitats Summary.....	18

### **Introduction**

The coastal zone is an intrinsic part of the northwest culture. For Native Americans, the coast has been a provider of food and a transportation zone for millennia. European settlement also concentrated along the state's shorelines. These trends continue today: the coastline is an economic, esthetic, and geographic focal point for residents of Washington. It is the window between uplands and the world for transportation, it provides recreation, residential amenities, and sites for waste disposal, and continues to be an important Tribal harvest and cultural resource.

Use of the shoreline is more intense than ever. Humans directly and indirectly impact the coast everywhere. These impacts include degradation of water quality from urbanized watersheds, pollution of shellfish beds, loss of coastal wetlands, loss of coastal riparian vegetation, and invasion of exotic plants and animals. Fortunately there is an increasing awareness of the importance and fragility of coastal ecosystems. Programs are now in place to restore habitat, to improve water quality, and to conserve rare and endangered habitats.

The coastal zone is a unique part of this planet's ecosystem. It is the interface between land, air, and ocean, and shares elements of the terrestrial, marine and atmospheric environments. The ecological processes controlling coastal ecosystems are complex. Basic inventories of the location and abundance of abiotic and biotic coastal resources contribute immeasurably to our understanding of these processes. Such an inventory for the entire marine and estuarine shoreline has never been completed. By carefully mapping our resources, we can increase our knowledge of where features and organisms occur, and build an understanding of complex coastal processes.

### **Project Purpose**

The goal of the Washington State ShoreZone Inventory project is to provide a consistent, state-wide description of shoreline habitats. We hope that this information will support more informed decision-making about the uses of the coastal zone. The ShoreZone Inventory dataset has a wide range of applications for habitat management and for conserving sensitive resources.

### **The ShoreZone User's Manual**

In order for the ShoreZone Inventory to be useful tool for resource management, users need a basic understanding of the structure of the data and appropriate uses. The high resolution of these data – features as small as individual boat ramps are mapped – means that associated datasets are large and complex. This manual was designed to help people use the data:

- To provide a simple overview of the ShoreZone Inventory and how it works.
- To explain to users how the data are organized in order to tap the potential of this dataset by accessing and manipulating the data for their management applications.
- To provide a key for the codes in the databases.

- To provide examples of applications.
- To explain limitations of the data.

## **History of the ShoreZone Inventory Project in Washington State**

Two agencies worked primarily on the Washington State ShoreZone Inventory. The Washington State Department of Fish and Wildlife (WDFW) began mapping in 1994 as a pilot project. WDFW collected survey data and completed data analysis for San Juan Island in 1994 and for the outer coast and the Strait of Juan de Fuca in 1995. In 1997, WDFW collected survey data for a portion of Puget Sound.

In 1998, the Nearshore Habitat Program in the Washington State Department of Natural Resources (DNR) adopted the ShoreZone Inventory project. It collected survey data for the remaining portions of the shoreline in 1999 and 2000, and completed data analysis for all of the surveys. The Nearshore Habitat Program altered the data structure of the ShoreZone Inventory slightly to increase ease-of-use. A series of fields were also added that describe anthropogenic features, translate codes for biota, form, and material fields, and convert the BC CLASS shoreline classification into two local classification systems (the Natural Resource Damage Assessment (NRDA) Classification System and Washington State Marine and Estuarine Classification System.)

## **Acknowledgements**

The Washington State ShoreZone Inventory was derived from the British Columbia Physical Mapping System (Howes et al, 1994) and Biological Shore-Zone Mapping System (Searing and Frith, 1995). These mapping standards are defined by the Resource Inventory Committee of British Columbia. Don Howes, of the BC Land-Use Coordination Office in Victoria, BC, has been instrumental in the development of the standard in British Columbia. He also provided conceptual support for the inventory efforts in Washington State. Carol Ogborne provided valuable technical assistance.

The Washington State ShoreZone Inventory is the product of years of work by many coastal mappers in the Pacific Northwest. Individuals that have contributed substantially to the development of this system include (in alphabetical order): W.C. Austin, H. Berry, B. Bookheim, J. Carleton, M. Dethier, M. Dunn, B. Emmett, D.L. Forbes, H.R. Frith, R.D. Gillie, D.E. Howes, R. Hunter, P. Lewis, M. Morris, M.J. Miles, N. McFadden, E.H. Owens, P.D. Reimer, G. Searing, A. Sewell, G.C. Schoch, T. Mumford, K. Warheit, P. Wainwright, M. Wayne. Through their ideas and comments, these mappers improved the system and its application for land use and resource applications.

John Harper of Coastal and Ocean Resources, Inc in Sydney, BC, oversaw the entire Washington State mapping project and was the primary geomorphologist. John's expertise was invaluable in applying the mapping system to Washington State. He was almost always patient with the detail-oriented Nearshore Habitat Program biologists.

Megan Dethier of University of Washington in Friday Harbor, WA, was the primary biologist for the project. Mary Morris of Archipelago Marine Research in Victoria, BC, also worked as a project biologist and provided conceptual support for the system adaptation to Washington State. Helen Berry completed the biology for the 'estuary gap' areas.



John Carleton and Ken Warheit of the Washington State Department of Fish and Wildlife began the mapping effort in 1994. They deserve credit for convincing resource managers in Washington State of the usefulness of the inventory system.

Helen Berry and Tom Mumford were the project managers for the ShoreZone Inventory in the Nearshore Habitat Program at the Washington State Department of Natural Resources. Betty Bookheim and Amy Sewell helped throughout the project with ecological review of data and documentation in the field and in the office. Betty Stephens provided much needed expertise in data design and data integrity testing. Linda Tamayo provided both GIS expertise and html programming skills. Martha Marrah completed substantial GIS work, especially the extensive corrections to the digital shoreline. Elizabeth Lanzer provided design guidance during early stages of the project.

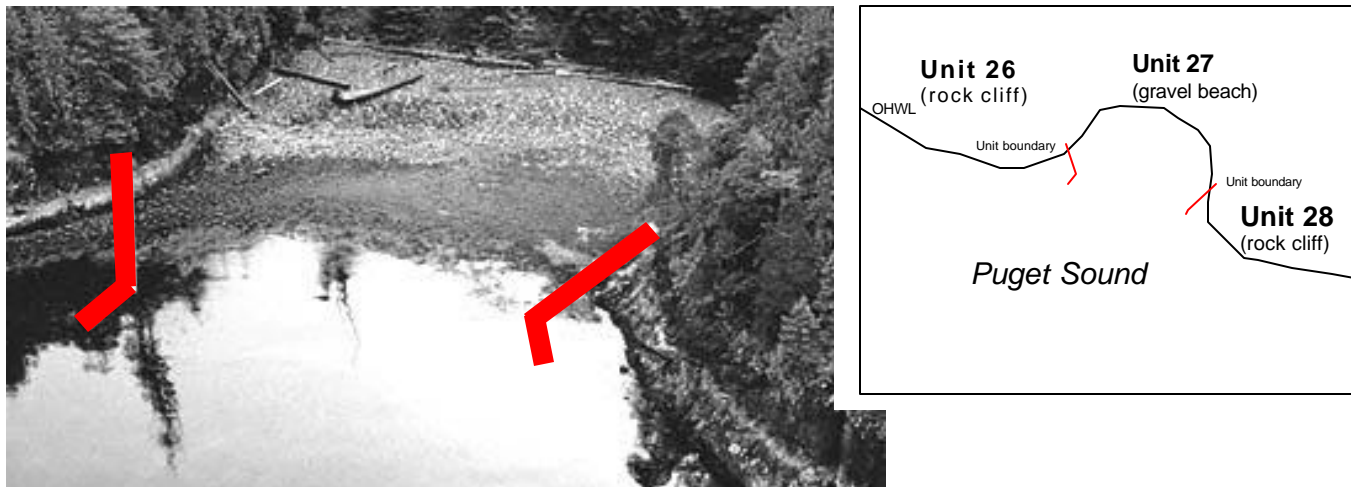
# SHOREZONE INVENTORY SYSTEM OVERVIEW

## Introduction

The challenge of a mapping system is to characterize features of interest into simple, discrete, and useful classes of information. For example, a good road map directs travelers by depicting roads, cities and other prominent features. Similarly, a useful shoreline map depicts important littoral features such as landforms, substrate, and biota. In both cases, the mapping system must identify and describe the features of interest. Unfortunately, variations in landforms and biota are often gradational, so a “system” or “methodology” is required to consistently identify and summarize important features. The ShoreZone Inventory System provides an efficient methodology for systematically characterizing shore-zone features from visual observations over large areas.

## ShoreZone Units

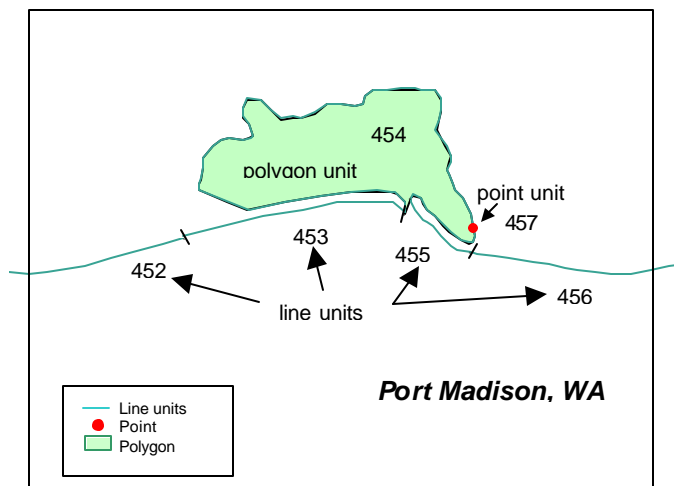
The basic concept underlying the ShoreZone Inventory System is that a shoreline can be subdivided into smaller pieces, and the characteristics of each piece can be described and recorded. The primary data division is the *unit* (see Figure 1). *Units* are alongshore stretches of beach with similar geomorphological characteristics. In Washington State, the average *unit* length is 0.5 miles.



**Figure 1 Conceptual example of a unit in the ShoreZone Inventory.** An oblique aerial photo of a gravel pocket beach bounded by rock cliffs. This is a good example of the type of feature that would be represented as a *Unit*. The spatial extent of the *Unit* is delineated on a map (above right) and detailed tabular information describing the *Unit* is recorded (right).

Sample Tabular Information	
Attribute	Unit
Unit ID	27
Length (ft)	85
Intertidal Zone Width (ft)	55
Shore Type	Gravel beach, narrow
Material	Cobble/boulder
Wave Exposure	Semi-protected
High marsh	Absent
Rockweed	Present
Soft-brown algae	None

*Units* can be illustrated as lines, polygons, or points (Figure 2). However, the vast majority of the *Units* are represented by lines. Lines are the primary data type because Washington’s shoreline is typically a long narrow feature with the alongshore length many times the across-shore width. Polygons are used to describe features with unique spatial characteristics that cannot be captured by a single line segment, such as convoluted marshes or extensive embayment mudflats. Points are used to identify features that are of interest to resource managers but are too small (in terms of alongshore length) to be represented by a line segment. (For more details on determining feature type, see the *Protocol for Unit Delineation* in the *Data Dictionary*.)



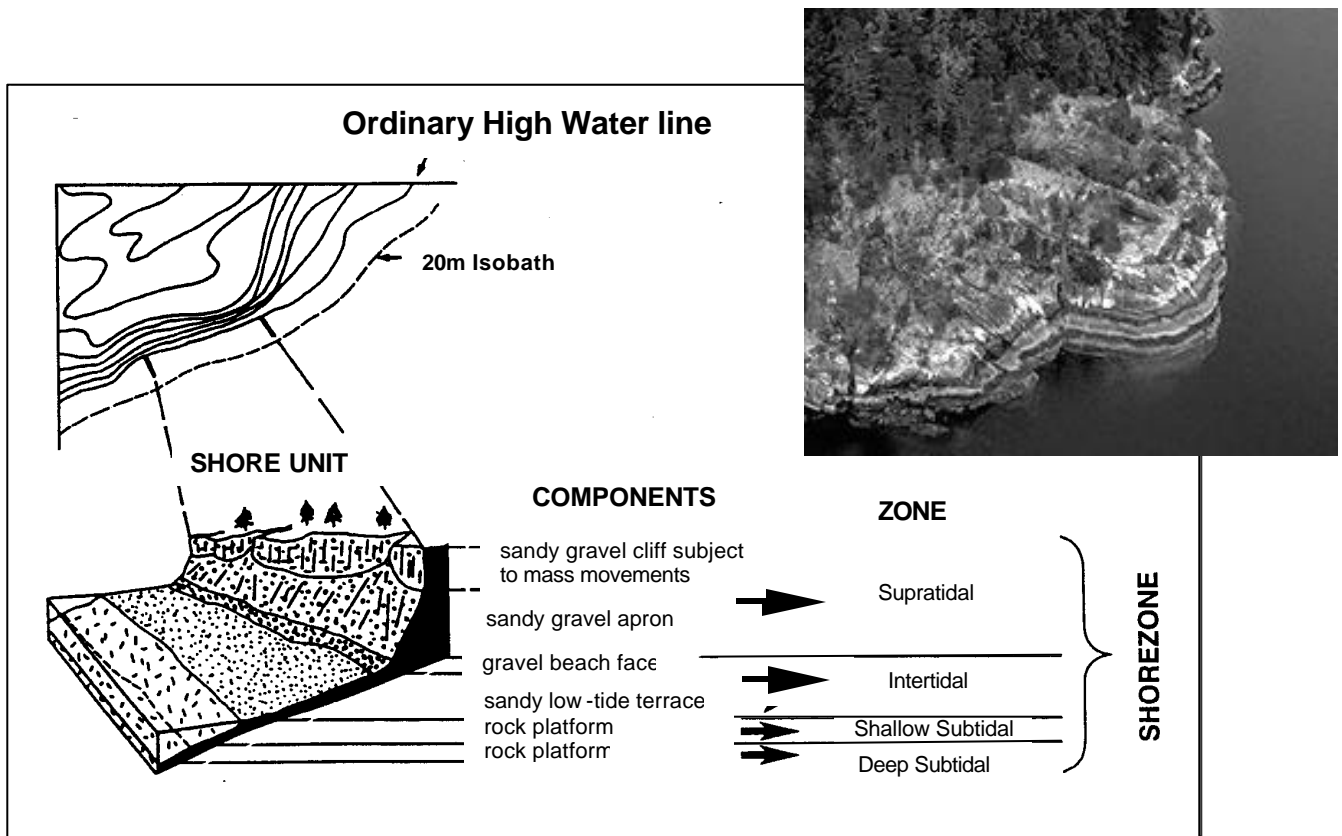
**Figure 2** A typical map of shore zone information showing the three types of units.

The map is based on the Ordinary High Water line (OHW) that has been subdivided into line segments (units 452, 453, 455, 456). Points represent small features (unit 457). Polygons represent features with unique spatial characteristics that are not captured by a single line segment (unit 454).

Information that describes the entire *unit* is recorded in the *Unit Table*. This information is then attached as attribute information to each spatial *unit* feature. See the *Data Dictionary* for a list of all of the tabular data fields that describe each *unit*.

## ShoreZone Components

The shoreline commonly exhibits across-shore variation in sediment composition and morphology that is correlated with tidal zonation (Figure 3). To capture this across-shore variation, we further subdivide each *unit* into across-shore *components*.



**Figure 3.** A conceptual diagram showing how each *Unit* is subdivided into across-shore *Components*. Shore zone features typically occur in across-shore bands that are correlated with tidal elevation. These bands are not mapped, but information about them is recorded in the *Component Database*.

Across-shore *components* are not mapped. Instead, a description of each subdivision is recorded in the across-shore (*XSHR*) *Component* table (Figure 4). Each across-shore *component* is described first according to the zone it occurs in (e.g., supratidal, intertidal or subtidal), and then it is numbered according to its sequence within the zone. Across-shore *components* are linked to *units* using a unique ID number. See the *Data Dictionary* for a list of all of the tabular data fields that describe each *component*.

**Unit Data**

Each spatial record delineates one unit and includes tabular information describing the unit.

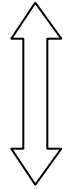


One-to-many

**Across-Shore Component Data**

For each unit, many associated across-shore component records describe the physical and biological features in detail. The location of each across-shore component is first described according to the zone it occurs in (A=supratidal, B=intertidal, C=subtidal). It is possible to have multiple components per zone. Within each zone, each across-shore component is numbered sequentially (i.e., A1, B1, B2, C1).

Line Units			
Unit ID	Shore Type	Length (ft)	Wave Exposure
1	Man-made	1460	Semi-protected
2	Sand flat	2106	Protected
3	Cliff w/ gravel & sand beach	1210	Exposed



Across-Shore Components					
Xshr ID	Unit ID	Zone	Comp	Form & Material	Biology
1	3	A	1	Steep cliff (bedrock)	Verrucaria Lichen
2	3	B	1	Beach face (pebble, cobble)	Rockweed
3	3	B	2	Beach w/ low tide terrace (sand, boulder)	Barnacles, Mussels, Non-floating kelp
4	3	C	1	Unknown	Eelgrass

**Figure 4 Conceptual diagram of ShoreZone Inventory Data Structure.**

Across-shore *component* data is designed to capture detail about the across-shore variation. For example, along a stretch of beach, the backshore seawall is comprised of concrete, the beach berm is comprised of logs on sand, the beach face is made of sand and pebbles, and the tidal flat with channels is comprised of sand and mud. This typical sequence of features are captured within the *Component Database*, where each component (e.g., seawall, beach berm, beach face, tidal flat) is a separate record in the database. A coding system records details on each component as if one was walking across the shore from the land (supratidal zone) to the water (subtidal zone). The codes describe the landforms and substrates (Table 1). In the ShoreZone system, the subtidal zone begins at approximately Mean Lower Low Water (0 feet elevation).

**Table 1. Examples of Form and Material Codes**

Form Codes	Form Translation	Material Codes	Material Translation
As:Ar	the primary Form is a seawall, but boat ramps also occur.	Ao;Aow	The seawall is concrete whereas the boat ramps are made of concrete and wood.
Bb	beach berm, usually at or near the MHWL (mean high water line)	At/Cspc	a log pile overlies the sand, pebble and cobble on the berm.
Bf	beach-face	Csp	the beach-face is comprised of sand and pebbles
Tt;Ttc	primarily a low tide flat but there is also a tidal channel across the flat.	Cs;Cs m	the tidal flat is sand, but the tidal channel is sand and mud.

## Biological Information

In addition to a description of the physical characteristics of a beach, each *Component* record includes a description of the living resources. The living resources are cataloged in terms of 23 conspicuous assemblages of species that are visible from the air. These assemblages are referred to as *Bio-Bands* because the algae, plants and animals create a well-defined series of across-shore color bands (Figure 3, photo inset). Each *Bio-Band* is named for the most prominent species in the band or by the general description of the species assemblage. The abundance of each band is recorded as either absent, patchy or continuous. In addition to appearing in the across-shore *Component* table, *Bio-band* information is also summarized at the *unit* level for ease-of-use. See the *Data Dictionary* for a list of the *Bio-Bands*.

### Methods Summary

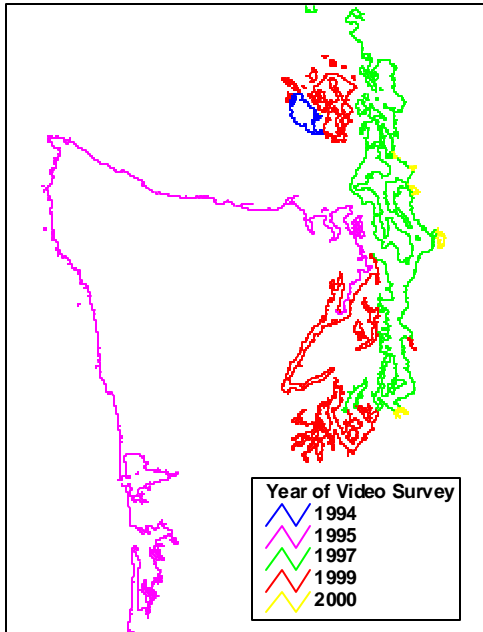
Between 1994 and 2000, we inventoried all of Washington's coastal shoreline with low elevation, helicopter surveys. The inventory protocols were based on the British Columbia ShoreZone Mapping System standards (Howes *et al.*, 1994., Searing and Frith, 1995). This system classifies the shoreline into homogeneous stretches (or *units*) based on key physical controlling factors and then describes physical and biological features in each *unit*. The major steps in the project are described below. They were:

1. Collected aerial field data.
2. Mapped physical features.
3. Digitized *units*.
4. Calculated wave exposure.
5. Mapped biology.
6. Checked completed data for each area.
7. Fixed identified shoreline problems.
8. Assessed data content.
9. Combined data and Checked for validity and integrity.
10. Finalized data fields and formats.

In total, we inventoried 3067 miles (4936 km) of Washington's marine shoreline. A total of 8,736 *units* were delineated. The longest *unit* is 2.38 miles (38.3 km) while the shortest is 59 ft (18 m). For the entire coastline, the average length of a *unit* is 2198 ft (666 m), while in Puget Sound the average length is 1782 ft (540 m.).

### Step 1 – Collected Aerial Field Data

Aerial video imagery was the principal source of information for the ShoreZone Inventory. Data was collected between 1994 and 2000 (Figure 5). Helicopter-based aerial surveys were conducted during summer low tides in June and July. Imagery was collected during the lowest portion of the tides (generally below Mean Lower Low Water). Flying altitudes averaged 300 feet and flight speed averaged about 60 knots. The helicopter was generally positioned about 100 feet seaward of the low-water line to maintain a clear view of the shoreline.



**Figure 5. Aerial video acquisition by year**

Survey data were collected by a three-person crew that included:

- A *marine ecologist*, who shot 35mm slides of the shore zone and provided a continuous descriptive narration on shore-zone biota (recorded on one sound track of the videotape).
- A *coastal geomorphologist*, who operated the video camera (Figure 6) and provided a continuous descriptive narration of the shore-zone morphology and substrate (recorded on the second sound track of the videotape).
- A *navigator*, who operated the electronic navigation system, kept a manual log of the flight line track (for back-up), and provided a narration of geographic locations (recorded on the second sound track).





**Figure 6 Photograph of the coastal geomorphologist in filming position in the rear seat of the helicopter.**

Three to four hours of imagery were collected per day , covering about 300 to 350 km of shoreline. Survey products included:

- Digital flight line tracks with 1-sec fix marks.

Videotapes with GPS positions burned on to each image. A total of thirty-four, 2-hour videotapes cover the entire Washington coast.

- 35mm slide set that is referenced to the track line maps and to the video-commentary.

## **Step 2 – Mapped Physical Features**

The physical shore-zone characterization was completed by a geoscientist with specialized training in coastal morphology, nearshore oceanography, and coastal ecology. The “physical” mapper completed the *unit*, and *xshr* databases and delineated the *units* on DNR 1:12,000 orthophoto maps. Specific procedures include:

- Assembled videotapes, base maps (orthophotographs), and blank databases.
- Delineated *units* on maps and classified unit features in the *unit* database; (specialized procedures for identifying “point” and “polygon” shore features are outlined in the Protocol for Unit Type Delineation).
- Categorized across-shore components in the XHSR database.

- Categorized the shoreline modifications (seawalls, piers/docks, boat ramps).
- Noted spatial inaccuracies of the DNR shoreline.

For a detailed description of the physical mapping procedures see Howes *et al.* 1994 and Harper *et al.* 1999.

### **Step 3 – Digitized Units**

The ShoreZone Inventory line coverage was derived from the DNR digital shoreline coverage named water level line. The physical mapper delineated *units* on paper orthophotographs that were then digitized to divide the DNR shoreline into georeferenced line segments. Where appropriate, point features or polygons were used to characterize shore features (see the *Protocol for Unit Type Delineation*). Procedures were:

- Segmented digital shoreline into *units*.
- Assigned UNIT numbers to digital shoreline *units*.

### **Step 4 – Calculated Wave Exposure**

A simple GIS calculation model was run on the segmented shoreline to compute the fetch characteristics of each *unit*. The GIS model automates a large number of measurements to compute a modified effective fetch (see Howes *et al.* 1994). Procedures were:

- Ran exposure model on segmented shoreline to compute fetch characteristics for each *unit* (*exp\_calc* field in *unit* database).
- Reviewed model results and wave exposure data determined by the geomorphologist (*exp\_obser* field in *unit* database).
- Determined exposure class (*exp\_class* in *unit* database).

### **Step 5 – Mapped Biology**

Biological resources, or *bio-bands*, were interpreted by a marine ecologist from the aerial video imagery and 35 mm slides. Specific procedures were:

- Categorized the across-shore *bio-banding* for each *component* previously defined by the geoscientist.
- Categorized exposure and habitat categories in *bio\_exp* field in the *unit* database.
- Entered 35 mm slide numbers into the *unit* database.

Details of the procedures associated with the biological mapping are described within Searing and Frith (1995) and in Harper *et al.* (1999). Additionally, The protocol for classifying the biota is summarized in *Data Dictionary* under *Detailed 'Bio-band Code Descriptions* and is designed to provide the user with an estimate of confidence levels of the biological interpretations.

### **Step 6 – Checked Completed Data for Each Area**

After an area was mapped, a series of quality assurance procedures were used to ensure that the data set was internally consistent, that digital databases matched map data, and that coding was consistent. The most common problem identified in the QAQC procedures was mis-numbering of records in the spatial coverage and their “corresponding” tabular records.

### **Step 7 –Fixed Spatial Errors in the Shoreline**

The ShoreZone Inventory line coverage was derived from the DNR digital shoreline coverage named water level line. This line approximates Ordinary High Water line and marks the boundary between upland and areas affected by salt water. During the unit delineation phase, errors in the digital shoreline were identified by the geoscientist. These errors were then reviewed and corrected by the Nearshore Habitat Program staff. A staff biologist and a GIS expert worked together to fix the identified shoreline problems to more accurately reflect the true shoreline.

- Identified spatial errors in the shoreline.
- Fixed the errors in GIS.
- Updated spatial dataset and tabular data fields.

### **Step 8 –Assessed Data Content**

We reviewed the data content of priority fields in the *unit* and *component* tables using two information sources. In the summer of 2000, Nearshore Habitat Program biologists conducted ground surveys to assess the accuracy of the ShoreZone Inventory data. Additionally, ShoreZone data was compared digitally to other existing Nearshore Habitat Program data sets.

As a result of the review, a total of 450 fields were updated. Data changes were limited to observations that were remarkably different than the ShoreZone Inventory results. In order to maintain consistency throughout the data set, features that were found to be commonly missing from the inventory were NOT added. This included certain subtidal biological components such as red algae (RED) and *Gracilaria spp.* (GCA) that were more easily seen from ground surveys and more difficult to see from the helicopter.

- Chose biological and geographically diverse areas for ground surveys.
- Evaluated data fields: BC shoreline type, % of shoreline modification, # of piers and boat ramps, key vegetation classes.
- Reviewed existing Nearshore Habitat Program data sets describing marine vegetation.

- Updated key fields.

### **Step 9 – Combined Data and Checked for Validity and Integrity**

After classification and data entry were completed for all areas, the tabular and spatial data were combined into statewide files. Then, data validity and integrity tests were run on the entire data set. Each field was tested to confirm that all codes were valid. All records were also tested to ensure that each spatial feature had one corresponding and valid *unit* record, and many corresponding and valid *component* records. The data validity and integrity testing process required countless rounds of review and error correction.

### **Step 10 – Finalized Data Fields and Formats**

Following completion of data validity and integrity testing, we finalized the data structure and content. Text translation fields were created for the most commonly used codes. Final unique identifiers were added to the data. Tabular *unit* fields were joined to the spatial data. *Component* records were divided into separate tabular files for each spatial feature type.

Using the final data set, we created a series of easy-to-use themes that summarize the most requested physical and biological information.

## **Summary**

The ShoreZone Inventory is a valuable tool for coastal management because it characterizes many biotic and physical aspects of the shoreline over a large geographic area. To use the inventory appropriately, users need to be aware of its limitations. The inventory is a snapshot in time, collected rapidly. Many small features were missed. In this way, it is a conservative inventory of the actual extent of the resources. Its strength is regional, not site-specific.

## **Some Rules of Thumb Regarding Data Limitations**

We inventoried the shoreline from a helicopter flying at approximately 60 mph, 300 feet above the shoreline. The resulting video imagery is high resolution. Features the size of boulders and major biotic assemblages are visible. However, you cannot see features that are small, inconspicuous, buried in sediments, shaded by vegetation, or deep under water. A general rule of thumb for determining which features were recorded is to ask, “Could I have seen it from the window of a helicopter traveling at 60 mph and 300 feet above the ground?” The inventory is not designed to capture small features. Therefore, it is a conservative representation of the actual distribution of the resources.

The inventory divides the shoreline into units based on geology, not biology. Hence the natural breakpoints in beach morphology determined the breakpoints in the inventory units. As a result, biotic elements such as kelp or eelgrass beds may occur in the middle of a unit, or span several units.

The inventory is a snapshot in time. Some features are highly ephemeral, such as some vegetation, berms, log piles, and sand bars. Other features vary seasonally. Some algal bands (such as the sea lettuce *Ulva*, the red algae *Gracilaria*, or the bull kelp *Nereocystis*) occur only during summer months, while others such as eelgrass (*Zostera*) may be present year-round. Nothing can be inferred from this data set about what would be considered normal inter-annual or seasonal variation in abundance or occurrence from these data.

If a feature or biota is recorded as present, the user can be fairly confident that the feature or organism was present during the overflight. But if a feature is *not* recorded, it does not mean that the feature is absent within the unit. A good example is the occurrence of the sea lettuce *Ulva*. *Ulva* is often present in the subtidal of protected shorelines. It is usually obvious in the intertidal zone but is not visible in the subtidal zone from a helicopter. This is also true for other types of algae and eelgrass.

Wave exposure levels for a unit are considered maximum levels; actual exposure varies significantly over time.

The resolution of the data severely limits its usefulness as a change detection tool. Only extreme changes over large areas could be inferred from the data.

The inventory extent, the tidal datums, and the inventory boundaries are approximate. The inventory extent was determined based on the DNR digital shoreline. This line approximates Ordinary High Water (OHW), with many known deviations. The division between estuarine and fresh-water environments was not surveyed; it was based loosely on the National Wetlands Inventory. In some cases, flight logistics made it difficult to capture the entire extent of estuarine habitat. As a result, small inlets, tributaries, backshore lagoons and transitional marshes were omitted. In contrast to NOAA's defined datums, the subtidal zone begins approximately at Mean Lower Low Water (0 feet) within the ShoreZone Inventory.

The inventory is a regional characterization and screening tool. It is not site specific, and it should not replace site-specific surveys. However, it can complement site-specific surveys by providing a regional context.

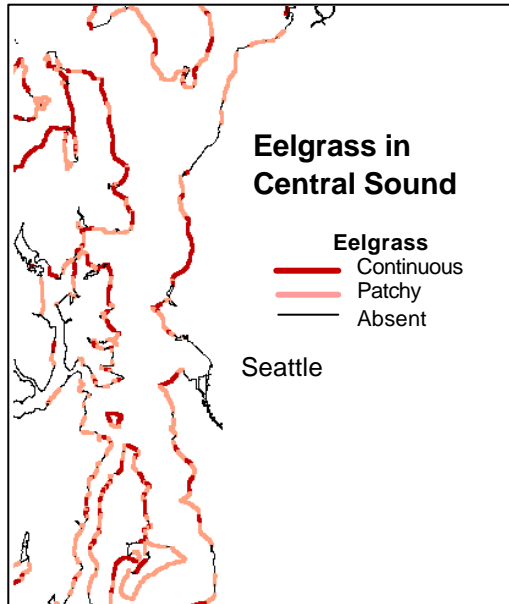
The ShoreZone Inventory data should be cited as follows: Nearshore Habitat Program. 2001. The Washington State ShoreZone Inventory. Washington State Department of Natural Resources, Olympia, WA.

The Washington State ShoreZone Inventory User's Manual should be cited as follows: Berry, H.D., J.R. Harper, T.F. Mumford, Jr., B.E. Bookheim, A.T. Sewell, and L.J. Tamayo. 2001. The Washington State ShoreZone Inventory User's Manual. Nearshore Habitat Program, Washington State Department of Natural Resources, Olympia, WA.

## **Examples of Data Applications**

ShoreZone Inventory data can be used in a wide variety of research and management applications. We have provided three brief examples below.

Map eelgrass distribution: Knowing the location of habitats of value is essential to formulating habitat management strategies. For example, eelgrass (*Zostera sp.*) is recognized as important fish and wildlife habitat. Eelgrass is also protected by policies such as the WDFW Hydraulic Permit Application and the Shoreline Management Act. Figure 7 shows eelgrass distribution along the eastern side of Central Basin. King County is using this ShoreZone information for shoreline planning. Any of the ShoreZone Inventory information can be displayed on maps.



**Figure 7 Distribution of eelgrass in Central Sound, based on ShoreZone Inventory interpretation of 1997 aerial video imagery.**

Estimate the extent of shoreline modification

Shoreline modification such as bulkheading has been identified as an important indicator of human impact on habitat health. Shoreline modification leads to direct habitat loss through conversion, and indirect habitat loss through alteration of nearshore processes and sediment budgets. Queries of the ShoreZone Inventory data show that approximately one-third of Washington State’s shorelines have been modified. The extent of modification varies widely among regions, and is correlated with both human and environmental factors. Unconsolidated shorelines with high population densities tend to be more highly modified, for example 79% of the eastern side of Central Basin has been modified. The rocky outer coast, which is not extensively developed, has little shoreline modification. This type of numerical data analysis is possible with the ShoreZone Inventory data.

Characterize shoreline habitats in an area

A first step in many research and management projects is to characterize the natural resources in an area. ShoreZone Inventory data can be used to produce a regional summary of the abundance and distribution of habitats (Table 2). For example, in Carr Inlet, wide sand flats are the most common shoreline type, followed by narrow sand and gravel beaches. Eelgrass beds are present along a quarter of the inlet. Carr Inlet has a relatively high percentage of salt marshes, compared to other areas in the southern and central Puget Sound. Approximately half of the shoreline in Carr Inlet has been modified by bulkheads or seawalls.

**Table 2. Carr Inlet Shoreline Habitats Summary (percentage of total).**

<b>Shoreline Type</b>		
	Wide Sand Flats	25%
	Narrow sand and gravel beaches	23%
	Organics and fine sediments	19%
	Man-made	2%
	Wide sand and gravel flats	10%
	Narrow sand beaches	10%
	Mudflats	7%
Wide Sand beaches	4%	
<b>Living Resources</b>		
	Eelgrass	23%
	Salt marsh	16%
	Green algae	14%
	Non-floating kelp	3%
Dense oysters	5%	
<b>Modification</b>		49%



### Data Summary

This section describes the ShoreZone Inventory digital data. The data set is made up of spatial and tabular Geographical Information System (GIS) files. You will need ARC/INFO, ArcView or another GIS application to use the data. ArcView users can work with the data in the provided ArcView Project (.apr) files. Users without GIS software can download ArcExplorer from the ESRI web site free-of-charge.

The inventory data is in two formats:

- Easy-to-use ShoreZone themes show the most-requested inventory information.
- The complete Washington State ShoreZone Inventory includes the entire data set.

### ShoreZone Themes

Many data requests to the Nearshore Habitat Program center around a few topics of interest. To answer these frequently asked questions, we created themes from the ShoreZone Inventory. The themes include information on physical and biological features. Each theme is an ArcView shape file. ArcView users can work with the themes in the ArcView Project file szthemes.apr. There are three views provided in the project; Biological Themes, Physical Themes, and *Unit Summary*.

The themes are summarized below. A detailed description of the themes and how they were created is included in *The Data Dictionary*.

Unit Summary: summarizes the physical and biotic ShoreZone Inventory information in its attribute table. All codes have been translated into text.

Substrate Summary: divides the shoreline into 7 basic shoreline types based on substrate type.

Shoreline Type: divides the shoreline into 15 shoreline types commonly used in British Columbia. This classification is a simplification of the BC shoreline classification. The BC shoreline classification (*bc\_class*) is also listed, along with Dethier's (1990) A Marine and Estuarine Classification System for Washington State and the National Resource Damage Assessment (NRDA) classification.

Shoreline Modification: shows the percentage of anthropogenic shoreline modification in each line *unit*. Information on other anthropogenic features is also included in the attribute table, such as the number of docks, ramps, piers, and slips.

Floating Kelp: shows line *units* where canopy forming kelp (*Macrocystis* and *Nereocystis*) is continuous, patchy or absent.

Nonfloating kelp: shows line *units* where nonfloating kelp (ie., *Laminaria sp.*, *Hedophyllum sp.*, etc) is continuous, patchy or absent.

All Kelp: shows line *units* where all kelp (both floating and nonfloating species) is continuous, patchy or absent.

Sargassum: shows line *units* where the non-indigenous brown alga *Sargassum muticum* is continuous, patchy, or absent

Eelgrass: shows line and polygon *units* where eelgrass (*Zostera marina* and *Zostera japonica*) is continuous, patchy, or absent.

Surfgrass: shows line *units* where surfgrass (*Phyllospadix spp.*) is continuous, patchy, or absent.

Seagrass: shows line and polygon *units* where seagrass (*Zostera spp.* and *Phyllospadix spp.*) is continuous, patchy, or absent.

Salt Marsh: shows line and polygon *units* where salt tolerant vascular plants (ie., *Salicornia virginica*, *Triglochin maritima*, *Carex sp.*, *Spartina sp.*) are continuous, patchy, or absent.

Dune Grasses: shows line *units* where dune grass (*Leymus mollis*) is continuous, patchy, or absent.

## **The Complete Washington State ShoreZone Inventory Data Set**

The ShoreZone Inventory data set is composed of *unit* information and associated across-shore *component* information. This section provides an overview of the data structure. (See the *Inventory System Overview* section for a conceptual summary of the inventory system.)

The *Data Dictionary* provides detailed information on the entire data set and on each field. ArcView users can work with the provided ArcView Project file (*szdata.apr*), it contains all of the spatial themes along with linked tables.

### Unit Information

Information on ShoreZone *units* is contained in three spatial feature shape files named: *szline*, *szpoly*, and *szpt*. Many fields describing each *unit* are contained in the spatial files as attributes. These fields are described in the *Spatial File Fields - Summary* section of the *Data Dictionary*. The ShoreZone Inventory is primarily a linear data set, so the line data is the most important feature type to use. In areas with extensive flats, it is also important to look at the polygon data. Point features describe features that are below the minimum mapping unit, but are important for a variety of management purposes.

There is one additional spatial data file associated with the line *units*. This point coverage contains a point feature at the boundary of each line *unit*. It is a useful visual tool for locating *unit* boundaries. It is named *szlnend*.

### Across-Shore Information

For each *unit* file, there is a corresponding file that contains detailed across-shore information about the *unit* (*xshrline*, *xshrpoly*, *xshrpt*). The across-shore records describe the supratidal, intertidal and subtidal zones within each *unit*. The zones are further divided into multiple components if there are multiple physical features within each zone.

For each *unit* record, there are many associated across-shore *component* records (i.e., a one-to-many relationship). The across-shore records can be related to the unit records by the *unit\_id* field.

### **For More Technical Information on the ShoreZone Inventory**

The Province of British Columbia has published standards describing the ShoreZone Mapping System. The reports fully document the system for geomorphology and biology professionals. The manuals are available over the web on the Government of British Columbia Resource Inventory Committee web site. The manuals are:

Howes, D.E., J.R. Harper and E.H. Owens 1994. Physical shore-zone mapping system for British Columbia. BC Ministry of Environment, Lands, and Parks, for the Coastal Task Force of the Resource Inventory Committee (RIC), RIC Secretariat. Victoria, B.C. 71p.

Searing, G.F. and H.R. Frith 1995. British Columbia biological shore-zone mapping system. Contract Report by LGL Resource Associates Ltd., Sidney, BC to the Land Use Coordination Office, BC Ministry of Environment, Victoria, BC. 46p.

Classification work of Megan Dethier provided the conceptual basis for linking the physical and biological information into repeatable habitat associations:

Dethier, M.N. 1990. A marine and estuarine habitat classification system for Washington State. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA. 56p.

### **To Contact The Nearshore Habitat Program**

For more information about the ShoreZone Inventory or other projects, check the Nearshore Habitat Program web site on <http://www.wa.gov/dnr/> or contact us at:

The Nearshore Habitat Program  
Department of Natural Resources  
P.O. Box 47014  
Olympia, WA 98504-7014  
(360).902.1600

## REFERENCES

- Dethier, M.N. 1990. A marine and estuarine habitat classification system for Washington State. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA, 56p.
- Harper, J.R., M.C. Morris and P.D. Reimer 1994. Shoreline habitat mapping San Juan Island, Washington. Contract Report by Coastal and Ocean Resources Inc. of Sidney, BC to the Department of Fish and Wildlife, Olympia, WA, 19p.
- Harper, J.R. and P.D. Reimer 1995. Review of aerial video imagery (AVI) applications and development of AVI standards for the Province of British Columbia. *In* Proceedings of the Third Thematic Conference on Remote Sensing for Marine and Coastal Environments, Seattle WA, p. 700-709.
- Harper, J.R., R.D. Gillie and M.C. Morris 1997. Biophysical shore-zone mapping of the outer Washington Coast. Contract Report by Coastal & Ocean Resources Inc. of Sidney, BC for the Department of Fish and Wildlife of Olympia, WA, 24p.
- Harper, J.R., M.C. Morris and P.D. Reimer 1999. Biophysical shore-zone mapping system for Washington state (draft). Contract Report by Coastal & Ocean Resources Inc. of Sidney, BC for the Department of Natural Resources of Olympia, WA, 108p.
- Howes, D.E., J.R. Harper and E.H. Owens 1994. Physical shore-zone mapping system for British Columbia. BC Ministry of Environment, Lands and Parks, Victoria, BC, 71p.
- Howes, D.E., P. Wainwright, R. Baird, L. Berg, J. Cooper, J.M. Haggarty, J.R. Harper, E.H. Owens, P.D. Reimer and K. Summers 1995. Oil spill response atlas for Southern Strait of Georgia. Environmental Emergency Services, BC Ministry of Environment, Victoria, BC, 317p.
- Morris, M., J.R. Harper, P.D. Reimer, H.R. Frith and D.E. Howes 1995. Coastal biotic mapping system using aerial video imagery. *In* Proceedings of the Third Thematic Conference on Remote Sensing for Marine and Coastal Environments, Seattle, WA, p.200-210.
- Searing, G.F. and H.R. Frith 1995. British Columbia biological shore-zone mapping system. Contract Report by LGL Research Associates of Sidney, BC to the Land Use Coordination Office, Victoria, BC, 46p.