Cumulative Effects Analysis for Wave Energy Offshore the Oregon Coast
A proposal to the Wave Energy Working Group of the Ocean Policy Advisory Council
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What is a Cumulative Effect?

- The Council of Environmental Quality's (CEQ) regulations for implementing the National Environmental Policy Act define cumulative effects as:
  - "the impact on the environment (... encompassing the environmental [ecology, biology, physical] parameters and human dimension (economic, social, etc.) which results form the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such actions (40 CFR § 1508.7)."

What is a Cumulative Effects Analysis?

- Takes a holistic approach (ecosystem-based management) to understanding impacts.
- Attempts to determine the cumulative environmental consequences of an action by delineating cause and effect relationships between multiple actions and resources, ecosystems, and human communities of concern.
- The analysis uses information to develop recommendations for management practices and actions that, where possible, will provide sustainability to socioeconomic interests while maximizing the long-term biological/physical integrity of the ecosystem.

Principles of Cumulative Effects 1

- Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions

- **Wave energy development** – The development of wave energy (also applicable to marine reserves or open-water aquaculture) off the Oregon Coast is reasonably forseeable. How can we learn from present development to forecast future development and impacts (negative, positive, or neutral) on the ecosystem and human communities.

Principles of Cumulative Effects 2

- Cumulative effects are the total effect, including direct and indirect effects, on a give resource, ecosystem, and human community of all the actions taken, no matter who (Federal, nonfederal, or private) has taken the actions.
  - Individual effects from disparate activities may add up or interact to cause additional effects not apparent when looking at the individual effects one at a time. The additional effects contributed by actions unrelated to the proposed action must be included in the analysis of cumulative effects.

- **Wave energy development** – We need to look at current ocean uses, the effects of those actions on the ocean to date, and overly the potential development of wave energy facilities to get a sense of future effects.

Principles of Cumulative Effects 3

- Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected.
  - Environmental effects are often evaluated from the perspective of the proposed action. Analyzing cumulative effects requires focusing on the resource, ecosystem, and human community that may be effected and developing an adequate understanding of how the resources are susceptible to effects.

- **Wave energy development** – This analysis should focus not only on the development of each specific wave energy facility up and down the coast, but also on how the ecosystem and human community (general economic, specific fishing interests, cultural aspects, etc.) could be affected. What are they key points of susceptibility that we need to consider?

Principles of Cumulative Effects 4

- It is not practical to analyze the cumulative effects of an action on the universe; the list of environmental effects must focus on those that are truly meaningful.
  - The boundaries for evaluating cumulative effects should be expanded to the point at which the resource is no longer affected significantly or the effects are no longer of interest to affected parties.

- **Wave energy development** – Perhaps this means that we need to think about the distance between wave energy facilities, the size of the parks, or the total number that could be placed along the Oregon Coast when conducting this analysis. Since we cannot realistically examine everything, what are the most fundamental impacts, i.e., develop a matrix with different rankings to identify important parameters.

Principles of Cumulative Effects 5

- Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries.
  - Resources typically are demarcated according to agency responsibilities, county lines, grazing allotments, or other administrative boundaries. Because natural and socio-cultural resources are not usually so aligned, each political entity may actually manages only a piece of the affected resource or ecosystem. Cumulative effects analysis on natural systems must use natural ecological boundaries and analysis of human communities must use actual socio-cultural boundaries to ensure all effects.
- **Wave energy development** – What is an appropriate ecological boundary to consider? It should be based on sound scientific principles. What socio-cultural boundaries exist on the Oregon Coast?

Principles of Cumulative Effects 6

- Cumulative effects may effect results from the accumulation (addition) of similar effects or synergistic interaction of different effects.
  - Repeated actions may cause effects to build up through simple addition (more and more of the same effect), and the same or different actions may produce effects that interact to produce cumulative effects greater than the sum of the effects.

- **Wave energy development** – Some believe that the placement of wave energy facilities could additively create more rocky reef habitat; the same facilities could work synergistically to produce changes in whale migration patterns.

Principles of Cumulative Effects 7

- Cumulative effects may last for many years beyond the life and action that caused the effect.
  - Some actions cause damage lasting for longer than the life of the actions itself (e.g., acid mining drainage, radioactive waste contamination, species extinction). Cumulative effects analysis needs to apply the best science and forecasting techniques to assess potential catastrophic consequences in the future.

- **Wave energy development** – Some believe that creation of rocky reef habitat will occur if anchoring systems are left in place.

Principles of Cumulative Effects 8

- Each affected resource, ecosystem, and human community must be analyzed in terms of its capacity to accommodate additional effects, based on its own time and space parameters.
  - Analysts tend to think in terms of how resource, ecosystem, and human communities will be modified given the action's development needs. The most effective cumulative effects analysis focuses on what is needed to ensure long-term productivity or sustainability of the resource.
- **Wave energy development** – How can wave energy development off the Oregon Coast be designed to ensure long term productivity and sustainability of ocean resources and the economic viability of the Coastal economies?

Types of Cumulative Effects

Cumulative effects can have varied effects depending on the project's size, scope, and geographic location. The development of wave energy projects off the Oregon Coast best fit into the following category: Multiple actions, Additive Process (Type 3).

Table 1-4. Types of cumulative effects

	Additive Process	Interactive Process
Single Action	**Type 1** — Repeated "additive" effects from a single proposed project. Example: Construction of a new road through a national park, resulting in continual draining of road salt onto nearby vegetation.	**Type 2** — Stressors from a single source that interact with receiving biota to have an "interactive" (nonlinear) net effect. Example: Organic compounds, including PCBs, that biomagnify up food chains and exert disproportionate toxicity on raptors and large mammals.
Multiple Actions	**Type 3** — Effects arising from multiple sources (projects, point sources, or general effects associated with development) that affect environmental resources additively. Example: Agricultural irrigation, domestic consumption, and industrial cooling activities that all contribute to drawing down a groundwater aquifer.	**Type 4** — Effects arising from multiple sources that affect environmental resources in an interactive (i.e., countervailing or synergistic) fashion. Example: Discharges of nutrients and heated water to a river that combine to cause an algal bloom and subsequent loss of dissolved oxygen that is greater than the additive effects of each pollutant.

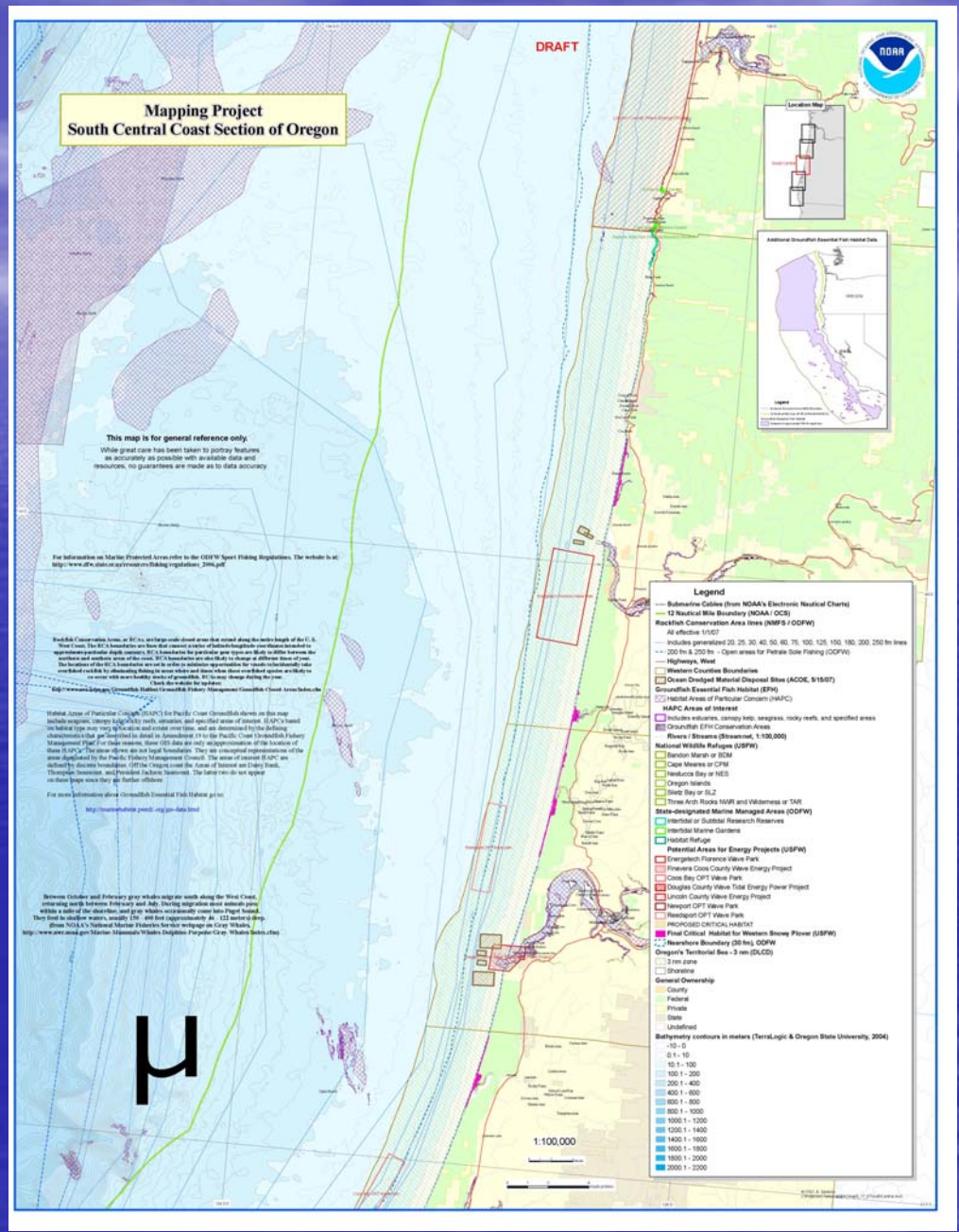
The 11 Steps of a Cumulative Effects Analysis

Step 1 Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.

Table 2-1. Identifying potential cumulative effects issues related to a proposed action

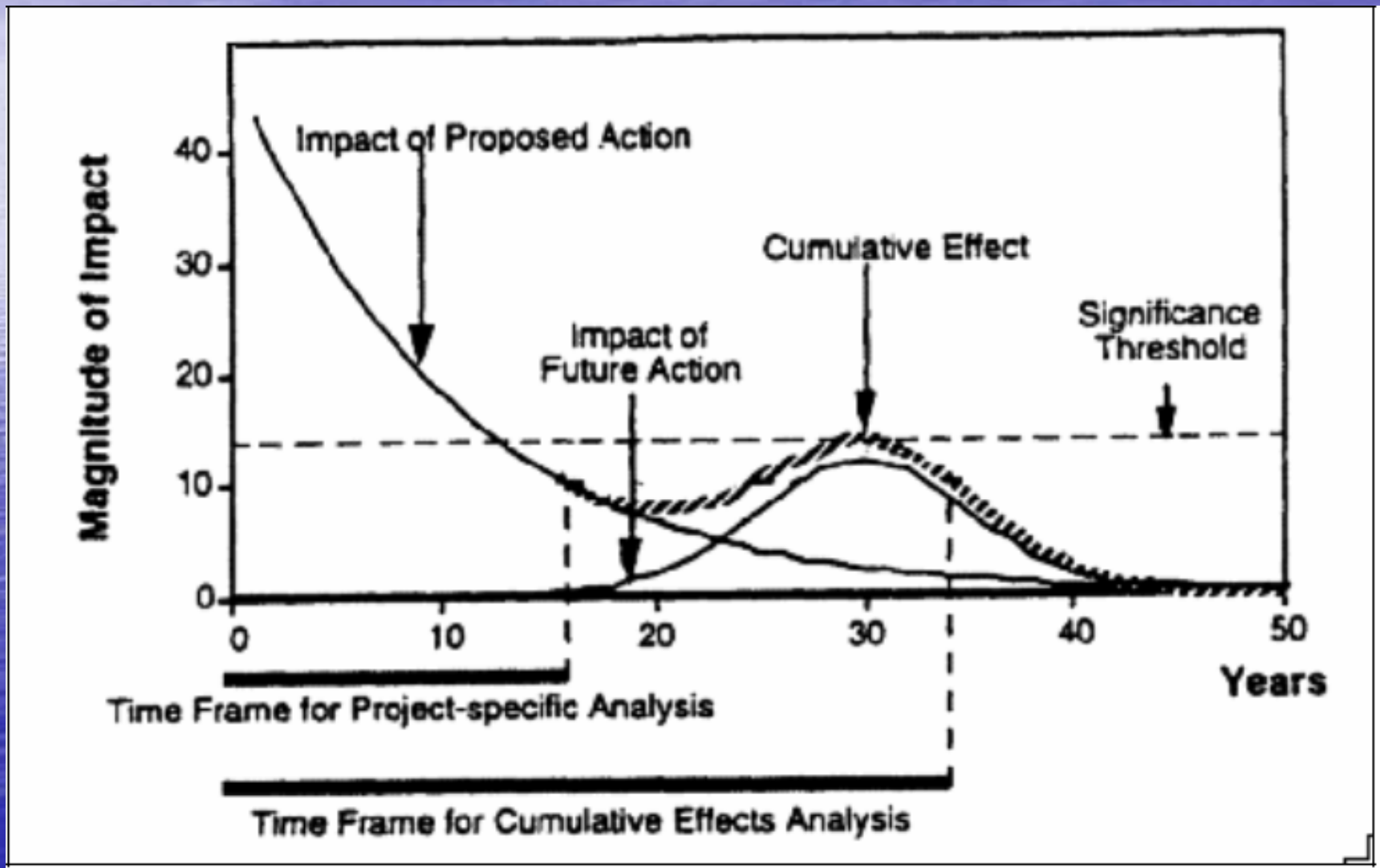
1.	What is the value of the affected resource or ecosystem? Is it: ▪ protected by legislation or planning goals? ▪ ecologically important? ▪ culturally important? ▪ economically important? ▪ important to the well-being of a human community?
2.	Is the proposed action one of several similar past, present, or future actions in the same geographic area? (Regions may be land management units, watersheds, regulatory regions, states, ecoregions, etc.) *Examples: timber sales in a national forest; hydropower development on a river; incinerators in a community.*
3.	Do other activities (whether governmental or private) in the region have environmental effects similar to those of the proposed action? *Example: release of oxidizing pollutants to a river by a municipality, an industry, or individual septic systems.*
4.	Will the proposed action (in combination with other planned activities) affect any natural resources; cultural resources; social or economic units; or ecosystems of regional, national, or global public concern? *Examples: release of chlorofluorocarbons to the atmosphere; conversion of wetland habitat to farmland located in a migratory waterfowl flyway.*
5.	Have any recent or ongoing NEPA analyses of similar actions or nearby actions identified important adverse or beneficial cumulative effect issues? *Examples: National Forest Plan EIS; Federal Energy Regulatory Commission Basinwide EIS or EA.*
6.	Has the impact been historically significant, such that the importance of the resource is defined by past loss, past gain, or investments to restore resources? *Example: mudflat and salt-marsh habitats in San Francisco Bay.*
7.	Might the proposed action involve any of the following cumulative effects issues? ▪ long range transport of air pollutants resulting in ecosystem acidification or eutrophication ▪ air emissions resulting in degradation of regional air quality ▪ release of greenhouse gases resulting in climate modification ▪ loading large water bodies with discharges of sediment, thermal, and toxic pollutants ▪ reduction or contamination of groundwater supplies ▪ changes in hydrological regimes of major rivers and estuaries ▪ long-term containment and disposal of hazardous wastes ▪ mobilization of persistent or bioaccumulated substances through the food chain ▪ decreases in the quantity and quality of soils ▪ loss of natural habitats or historic character through residential, commercial, and industrial development ▪ social, economic, or cultural effects on low-income or minority communities resulting from ongoing development ▪ habitat fragmentation from infrastructure construction or changes in land use ▪ habitat degradation from grazing, timber harvesting, and other consumptive uses ▪ disruption of migrating fish and wildlife populations ▪ loss of biological diversity

Step 2
Establish the geographic scope for the analysis.



Step 3

Establish the time frame for the analysis



Step 4

Identify other actions affecting the resources, ecosystems, and human communities of concern

- This is where the analysis discusses current ocean uses like fishing interests, whale watching, existing refuges, etc.

Step 5

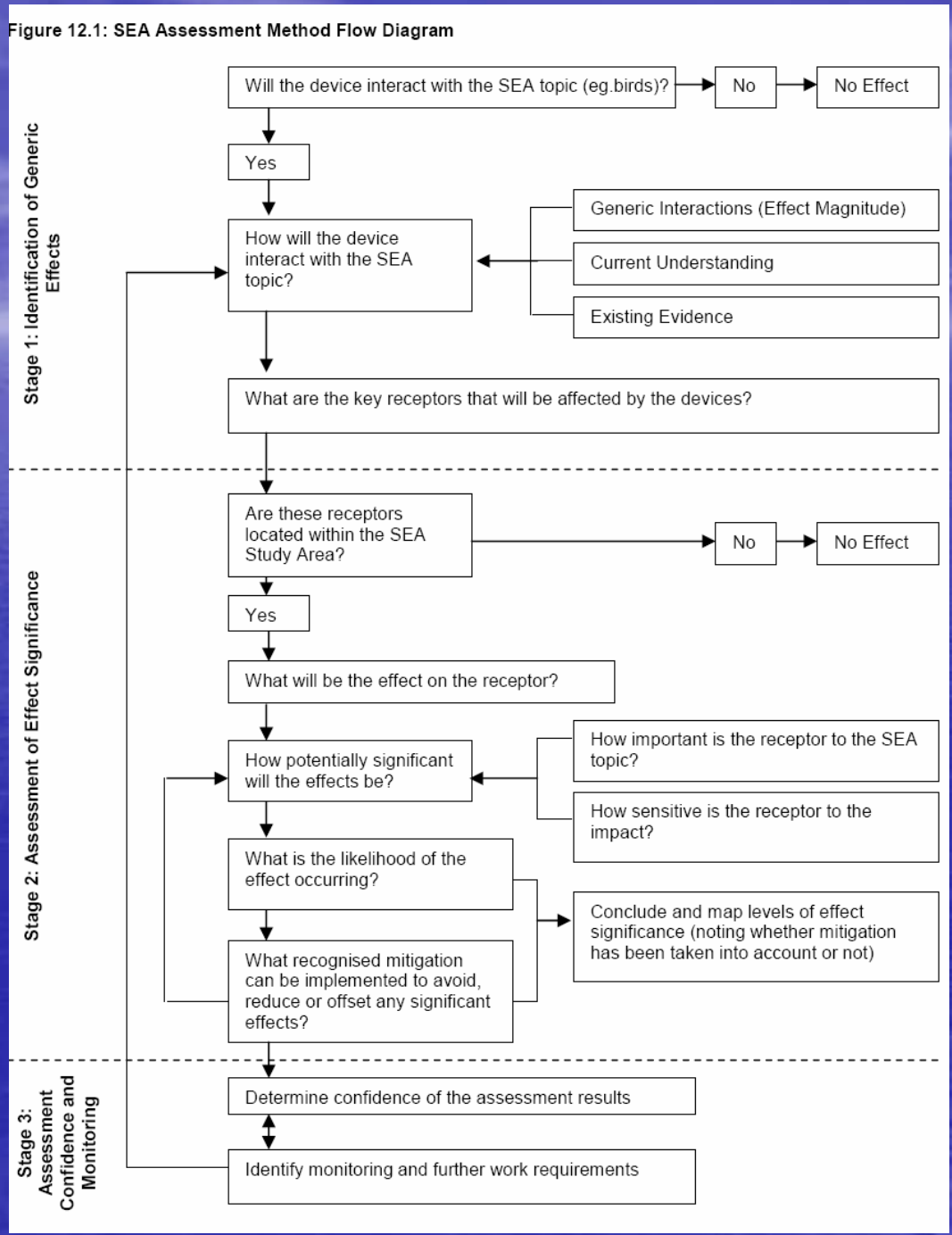
Characterize the resources, ecosystems, and human communities identified during scoping in terms of their response to change and capacity to withstand stresses.

- This information could come from the Reedsport project information and the Could come from the October, 2007 workshop on ecological effects of wave energy off the Oregon Coast.

Step 7
Define a baseline condition for the resources, ecosystems, and human communities.

- Information for this could come from the Reedsport project, and other existing information sources.

Step 8
Identify the important cause and effect relationships between human activities and resources, ecosystems, and human communities.



Step 9

Determine the Magnitude and Significance of Cumulative Effects

Table 4-1. Example table using quantitative description of effects (within a given level of uncertainty) on various resources

Resource	Past Actions	Present Actions	Proposed Action	Future Actions	Cumulative Effect
Air Quality	No effect on SO_2	20% increase in SO_2	10% increase in SO_2	5% increase in SO_2	35% increase in SO_2
Fish	50% of 1950 population lost	2% of fish population lost	5% increase in fish population	1% of fish population lost	48% of 1950 fish population lost
Wetlands	78% of presettlement wetlands lost	1% of existing wetlands lost annually for 5 years	0.5% of existing wetlands lost	1.5% of existing wetlands lost annually for 10 years	95% of presettlement wetlands lost in10 years

Step 10

Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.

- Very Important Outcome – The analysis should result in list of recommendations on industry development along the Oregon Coast.
- The Territorial Seas Plan could cross-checked against the analysis to ensure consistency with state policy on ocean conservation.

Step 11

Monitor the cumulative effects of the selected alternative and adaptive management.

- Information coming from the Reedsport project could be used to make recommendations for future industry development.

Potential Methods for Analyzing Cumulative Effects

- **Checklists** help identify potential cumulative effects by providing a list of common or likely effects and juxtaposing multiple actions and resources – potentially dangerous for the analyst that uses them as a shortcut to through scoping and conceptualization of cumulative affects problems.

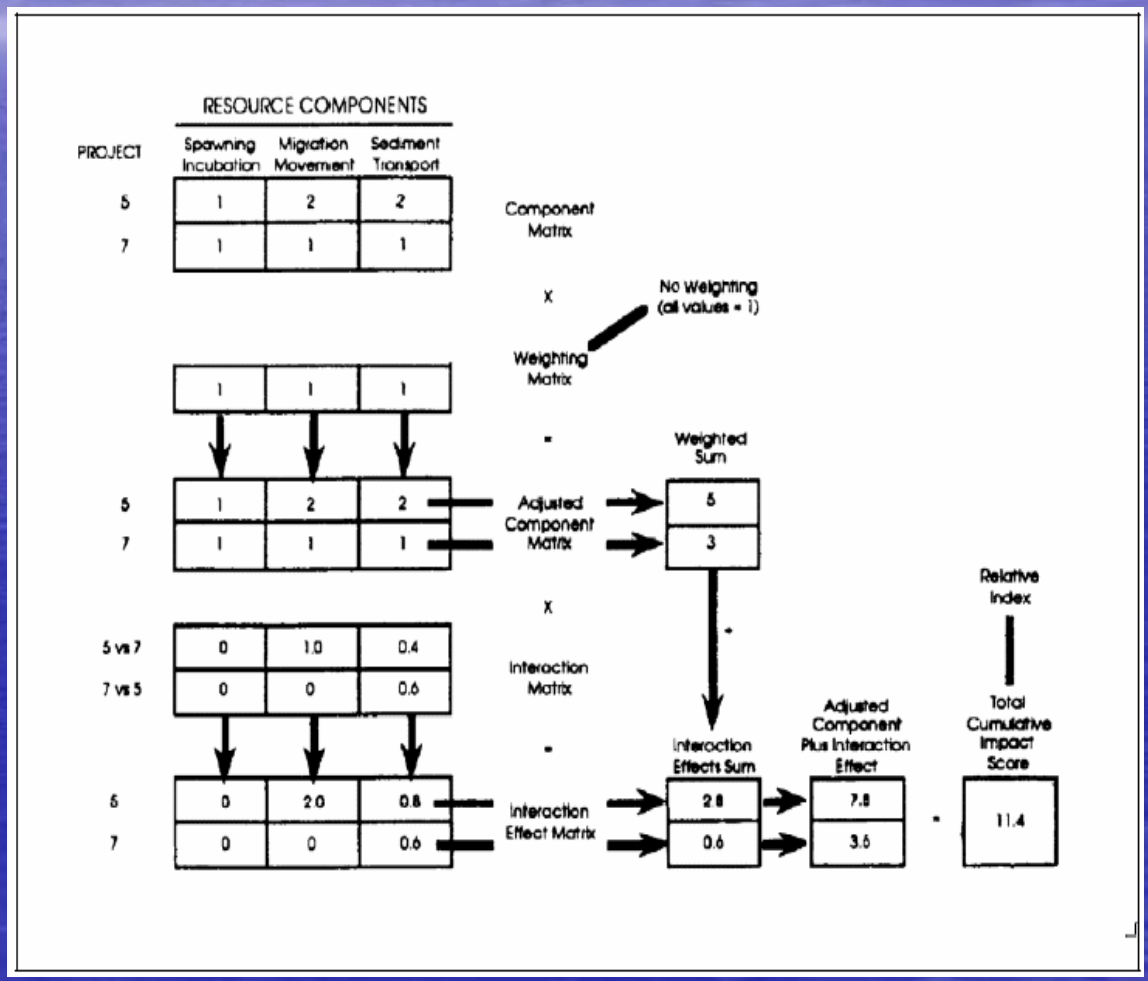
Table A-1. Hypothetical checklist for identifying potential cumulative effects of a highway project

Potential Impact Area	Proposed Action			Past Actions	Other Present Actions	Future Actions	Cumulative Impact
	Construction	Operation	Mitigation				
Topography and Soils	**			*			**
Water Quality	**	*	+	*	*	*	***
Air Quality		**		*			**
Aquatic Resources	**	**	+	*		*	**
Terrestrial Resources	*	*		*			**
Land Use	*	***		*		*	***
Aesthetics	**	***	+	*			**
Public Services	*	+				+	+
Community Structure		*			*		*
Others							

KEY: * low adverse effect ** moderate adverse effect *** high adverse effect
+ beneficial effect □ no effect

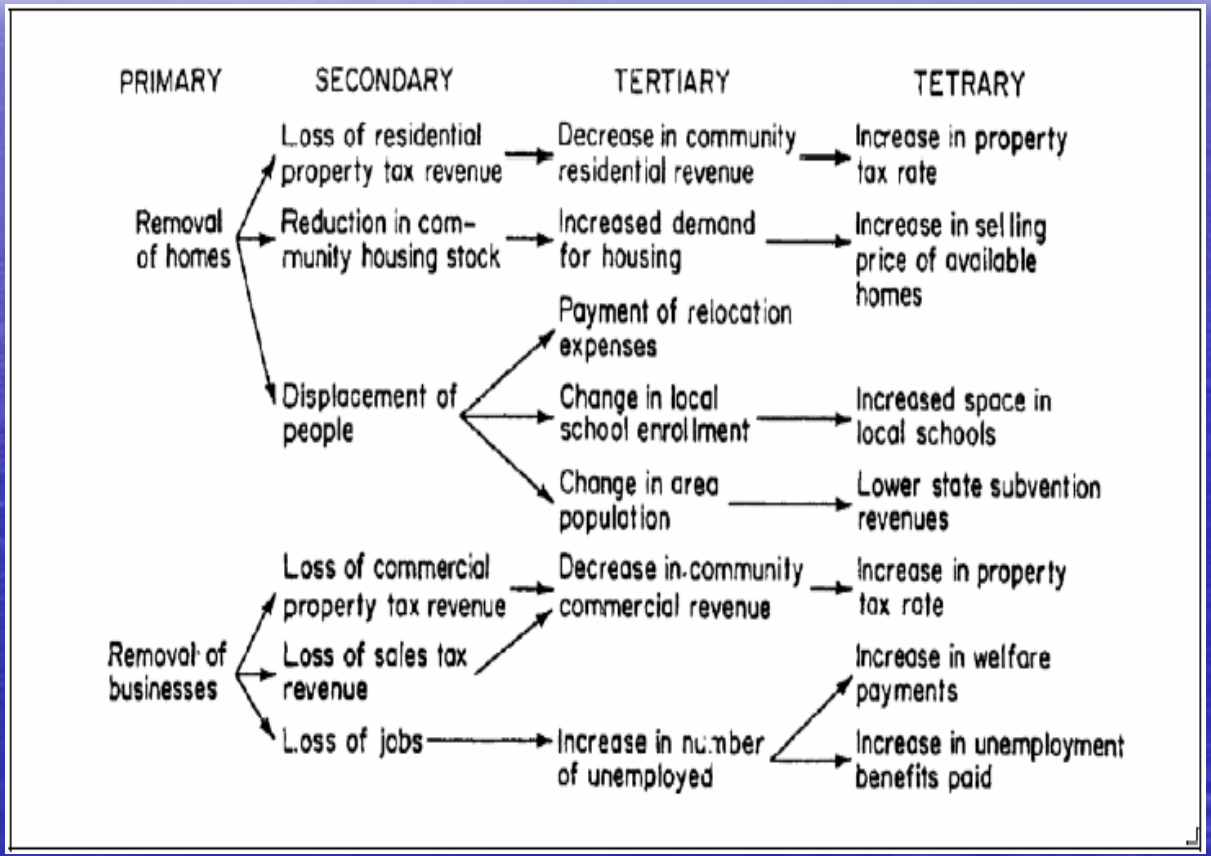
Potential Methods for Analyzing Cumulative Effects

- **Matrices** – Matrices' use the familiar tabular format to organize and quantify the interactions between human activities and resources of concern. Once even relatively complex numerical data are obtained, matrices are well-suited to combining the values in individual cells of the matrix (through matrix algebra) to evaluate the cumulative effects of multiple actions on individual resources, ecosystems, and human communities.



Potential Methods for Analyzing Cumulative Effects

- **Network and system diagrams** - Network and system diagrams are an excellent method for delineating the cause and effect relationships resulting in cumulative effects. They allow the user to analyze the multiple, subsidiary effects of various actions and trace indirect effects resources that accumulate from direct effects on other resources.



Potential Methods for Analyzing Cumulative Effects

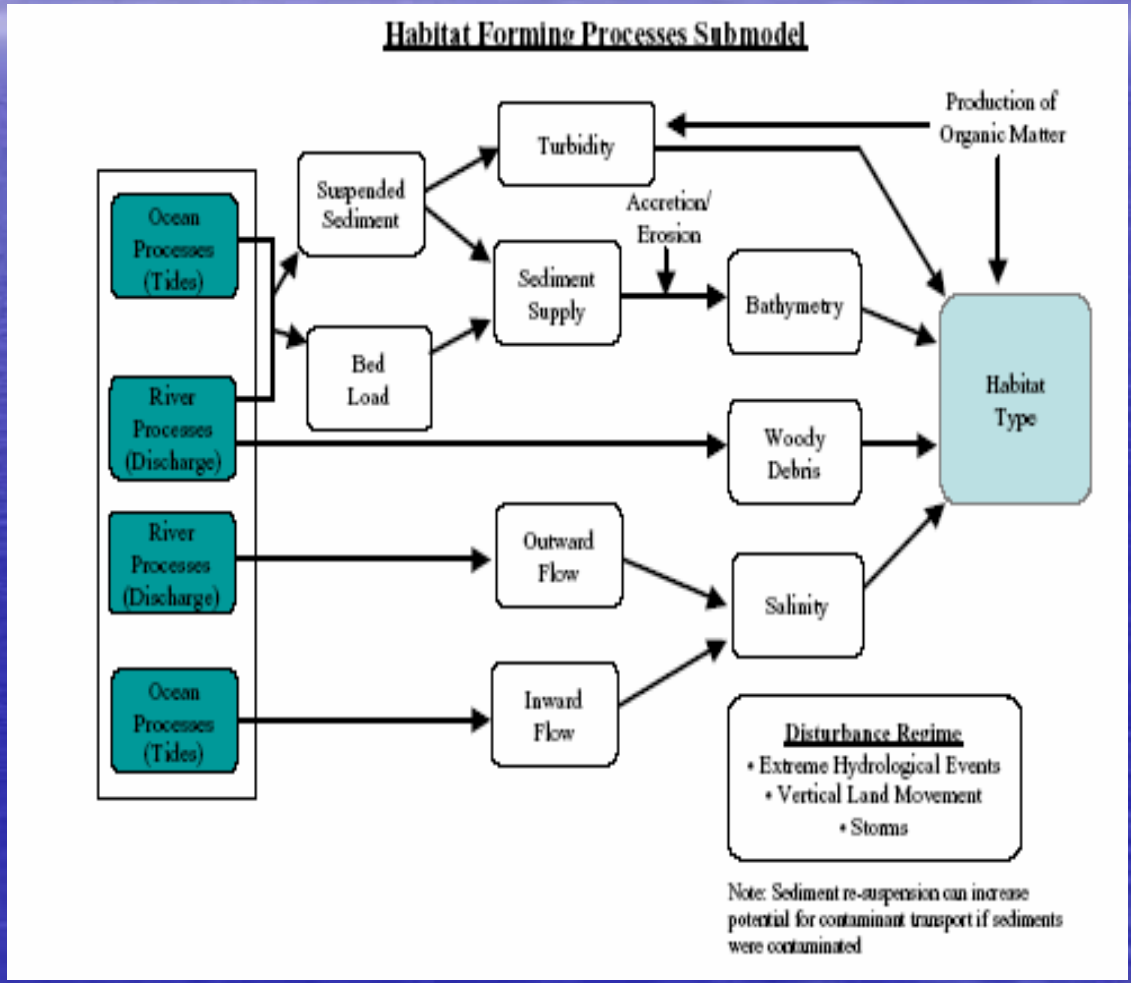
- **Trends Analysis** – Trends analysis assesses the status of a resource, ecosystem, and human community over time and usually results in a graphic projection of past or future conditions. Changes in the occurrence or intensity stressors over the same time period can also be determined. Trends can help the analyst identify cumulative effects problems, establish appropriate environmental baselines, or project future cumulative effects.

Table A-2. Habitat loss by historic period in Commencement Bay, WA (modified from USACE 1993)

Historic Period	Habitat Type	Historical Records of Lost Habitat	Total Lost Habitat (includes historical records and photographic evidence)	Acres Remaining
1877 - 1894	mudflat marsh	11 20	0 0	2,074 3,874
1894 - 1907	mudflat marsh	208 41	805 415	1,469 3,459
1907 - 1917	mudflat marsh	51 35	542 64	927 3,395
1917 - 1927	mudflat marsh	48 0	162 72	765 3,320
1927 - 1941	mudflat marsh	143 399	133 1,676	632 1,44
1941 - Present	mudflat marsh	105 1,557	412 1,587	187 57
TOTALS	mudflat marsh	566 1,052	1,54 3,814	

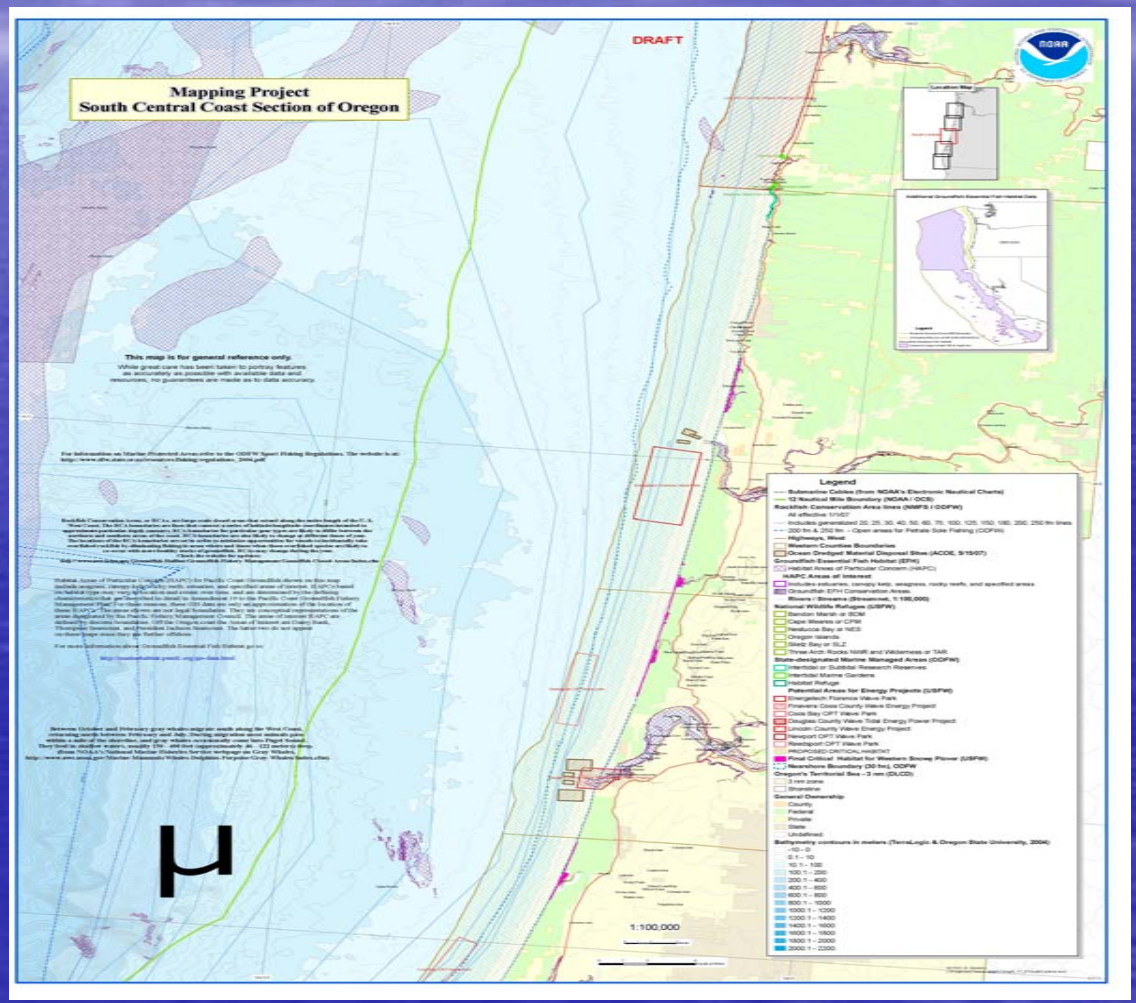
Potential Methods for Analyzing Cumulative Effects

- Conceptual Models – Conceptual models are an diagram that illustrates integrated physical and biological relationships. The conceptual model helps to clarify risks and uncertainties, guide the analysis of effects, and provide a framework for an adaptive management program.



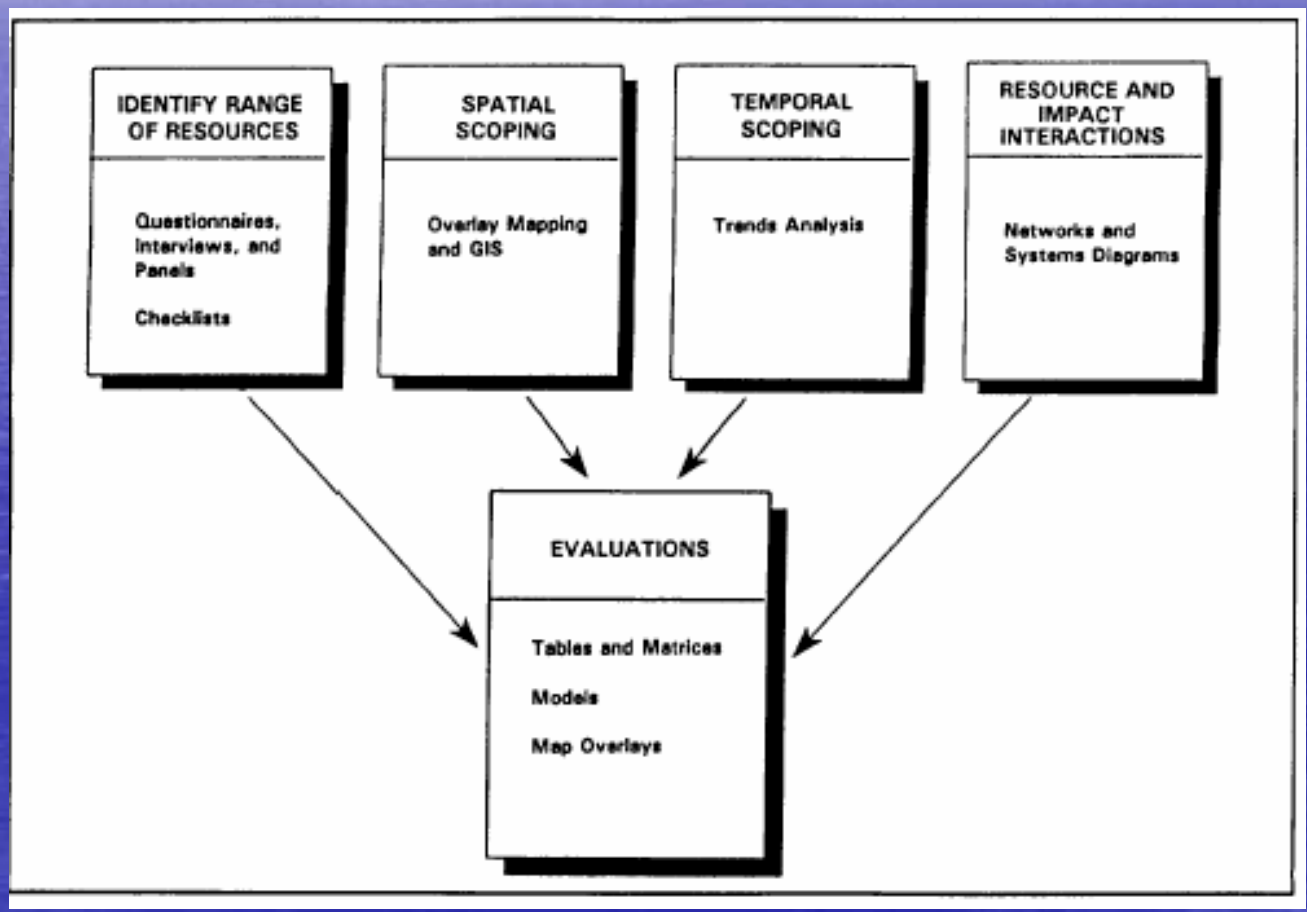
Potential Methods for Analyzing Cumulative Effects

- **Overlay GIS Mapping** – Overlay mapping and geographic information systems incorporate locational information into cumulative effects analysis and help set the boundaries of the analysis, analyze landscape parameters, and identify areas here effects will be the greatest. Map overlays can be based on either the accumulation of stresses in certain areas or on the suitability of each land unit for development.



Potential Methods for Analyzing Cumulative Effects

- Analysis techniques can be combined for the proposed analysis.



Important Points about this Analysis

- This is a “living analysis” in that information gained over time could be used to update the analysis and confirm forecasting of effects.
- A steering committee should be established to pick the contractor and oversee the analysis.
- An immediate potential funding source could be the Oregon Wave Energy Trust
- The analysis can be phased in over time, with the first phase devoted to information gathering and the second phase devoted to analysis and recommendation development.
- This analysis does not have to cost millions of dollars to produce.