Invasive species have transformed marine habitats around the world. The most harmful of these invaders displace native species, change community structure and food webs, and alter fundamental processes, such as nutrient cycling and sedimentation. Alien invasives have damaged economies by diminishing fisheries, fouling ships’ hulls, and clogging intake pipes. Some can even directly impact human health by causing disease (Ruiz et al. 1997). Although only a small fraction of the many marine species introduced outside of their native range are able to thrive and invade new habitats (Mack et al. 2000), their impact can be dramatic.

The impacts of invasions may be seen locally, but the drivers of biological invasion are, to an increasing degree, global. Unfortunately, there is a paucity of information on invasive species at the global scale. The Convention on Biological Diversity (CBD) has identified the need for “compilation and dissemination of information on alien species that threaten ecosystems, habitats, or species, to be used in the context of any prevention, introduction and mitigation activities” (CBD 2000). Most data have been compiled at local, national, or regional scales (Ricciardi et al. 2000). Data that do exist often do not have consistent formats or definitions, and are therefore not easily comparable (Crall et al. 2006). Many datasets also lack information regarding ecological and economic impacts, and are therefore unable to inform risk assessments or to catalyze effective policies across national borders.

Once alien species become established in marine habitats, it can be nearly impossible to eliminate them (Thresher and Kuris 2004). Interception or removal of pathways are probably the only effective strategies for reducing future impacts (Carlton and Ruiz 2005). With limited funds, establishing priorities is key, so that money allocated for prevention of invasions is well spent. Prioritizing actions requires knowing which species are likely to be most harmful to native ecosystems (Byers et al. 2002), their current distributions, and how they are likely to be transported to new regions.

This paper describes a new effort to quantify the geographic distribution of the threat of invasive species to marine biodiversity worldwide. We present an analytical framework that allows users to objectively compare marine invasions worldwide. Information on alien species that threaten ecosystems, habitats, or species, to be used in the context of any prevention, introduction and mitigation activities.” (CBD 2000). Most data have been compiled at local, national, or regional scales (Ricciardi et al. 2000). Data that do exist often do not have consistent formats or definitions, and are therefore not easily comparable (Crall et al. 2006). Many datasets also lack information regarding ecological and economic impacts, and are therefore unable to inform risk assessments or to catalyze effective policies across national borders.

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This paper describes a new effort to quantify the geographic distribution of the threat of invasive species to marine biodiversity worldwide. We present an analytical framework that allows users to capitalize on existing information by: (1) incorporating data from diverse sources in a uniform manner; (2) systematically scoring the threat of each alien species to native biodiversity; (3) collecting information by geographic units (marine ecoregions), so that data can be summarized and analyzed with other datasets at this scale; and (4) documenting introduction pathways for each species. Using the information compiled to date, we also present some initial findings from this dataset. This is not an exhaustive analysis, but illustrates the utility of the database, and provides some
new insight into patterns and processes of global marine invasions.

# Scope of the assessment

This assessment is focused on the global distribution patterns and impacts of alien species on native species and habitats in the coastal marine environment. Species that primarily occur in and modify human-managed waters (e.g., aquaculture) have been included, but only their impacts on native biodiversity are documented.

There are multiple ways to define “invasive species” (Lodge et al. 2006). Recognizing the limitations and practical needs of a global study, we use a broad definition that includes any species reported to have become established outside of its native range (Richardson et al. 2000; Rejmánek et al. 2002). This differs from the narrower definition used for public policy purposes, which requires that the species cause negative economic, environmental, or public health impacts (e.g., US Federal Executive Order 13112 1999; McNeely et al. 2001), but it allows incorporation of information from a broader array of data sources. We devised a threat scoring system to indicate the magnitude of species’ ecological impact and invasive potential within the global framework.

We report non-native occurrences by ecoregion, using a biogeographic classification recently developed for marine coastal environments (www.nature.org/MEOW; Spalding et al. 2007). Ecoregions are widely used for conservation planning and strategic analysis by major conservation NGOs (Olson et al. 2001). Marine ecoregions have been defined as “areas of relatively homogeneous species composition, quite clearly distinct from adjacent systems” (Spalding et al. 2007). They are contained within marine realms, which are defined as large areas of ocean in which biota share a similar evolutionary history due to isolation or other factors (Spalding et al. 2007). We selected these units of analysis because they are global in scale and commensurate with the resolution of the data in a way that is useful for ecologically guided, regional risk assessment. Additional research was often necessary to convert data reported by political units (e.g., countries, states) into biogeographic terms.

We developed our data collection methods to allow consistent documentation of information across taxa and habitats. Related ongoing assessments of terrestrial and freshwater invasive species will be reported elsewhere.

# Database development

We collected information on marine invasive species from a variety of sources and compiled the information in a geographically referenced database. In addition to non-native distributions by marine ecoregion, we documented habitat types, native distributions, and introduction pathways for each species. We also collected detailed information about the threat that each species posed to native biodiversity, using the scoring system described below. A description of our data scoring system is provided in WebPanel 1.

Input data were restricted to published sources or otherwise highly credible, publicly available datasets, with a robust scientific framework; all sources are referenced in the database. We initially targeted datasets that covered broad spatial scales and taxonomic groups. Regional, national, and some sub-national datasets, along with literature and internet resources, were used to supplement data gaps and provide information at a finer scale. Data collection is ongoing. The database is available online (www.nature.org/marineinvasions) and will be updated periodically.

## Threat scoring system

The number of alien species in a habitat does not indicate the level of threat posed to native biota or the damage already done. Many species establish in a new habitat with few disruptions, whereas others alter entire ecosystems or put native species at risk of extinction. We developed a threat-scoring system, based on several existing threat classification systems (Cal-IPC 2003; Salafsky et al. 2003; NatureServe 2004), to capture information on the threat posed by alien species.

Each invasive species was assigned a score (where data allowed) for the following categories: ecological impact, geographic extent, invasive potential, and management difficulty (Panel 1).

The “ecological impact” score measures the severity of the impact of a species on the viability and integrity of native species and natural biodiversity. For example, the green alga, *Caulerpa taxifolia*, was assigned the highest ecological impact score (4), based on its ability to out-compete native species and reduce overall biodiversity (Jousson et al. 2000). The sea slug, *Godiva quadricolor*, was conservatively assigned a lower score (2), because its only known impact is feeding on one taxon – other sea slugs – with no wider effects documented (Hewitt et al. 2002).

The ecological impact score was assigned globally for each species, not for specific occurrences. For consistency, this score reflects the most damaging documented impacts, although geographic variation and diversity of impacts were also noted where available. Where impact information was ambiguous, we were conservative and assigned a lower score. Because we are assessing the ecological impacts of invasive species, we have, to date, only included species for which we found documentation of ecological impacts, or lack thereof. We did not track how many species were excluded due to this criterion. We believe that the most harmful species are also the best documented, so that even at this stage, our work has a representative coverage of these most harmful species.

Species not captured in our database probably have relatively low ecological or economic impact and may include microorganisms whose introductions are largely
unrecorded and whose impacts remain poorly understood (Drake et al. 2007). “Geographic extent” captured the scale of each species’ invasive range. It was defined relative to ecoregion size, instead of by absolute units (e.g., area, length of coastline), to allow use across marine, freshwater, and terrestrial environments. “Invasive potential” is an estimate of the magnitude of the current or recent rate of spread and the potential for future spread after introduction to new habitats. The “management difficulty” score indicates the effort required to reverse the threat, remove the species, and/or manage its presence.

Threat scores were necessarily semi-quantitative, but they correspond to categories that differ substantially in threat level, with clearly defined parameters for assigning individual scores (WebPanel 1). This enabled us to include a broad range of information and to use the same categorical scoring across marine, freshwater, and terrestrial habitats.

**Pathways**

To consistently document introduction information in our database, we needed a classification of marine, terrestrial, and freshwater species pathways that would allow for the capture and summary of data with various levels of detail. We based our framework on the outline developed by the US National Invasive Species Council’s Pathways Team (Campbell and Kriesch 2003; revised by Lodge et al. 2006). This team developed “a system for evaluating the significance of invasive species pathways” into and within the US, broadly defining pathways as “any means that allows entry or spread of an invasive species” (Campbell and Kriesch 2003). Although this system includes routes of introduction that others may consider to be vectors (Carlton and Ruiz 2005) and categories are not always mutually exclusive, it allows the practical categorization of commonly reported information on pathways and vectors. We modified this system slightly, to better fit a global assessment and make category adjustments to allow effective gathering of data by species (Panel 2).

Using this framework, we documented all known and likely pathways for each species in our database. We only included pathways to new habitats, not methods for local dispersal. We were not geographically specific (e.g., we recorded that a particular species could be carried in ballast water, but not the specific ports between which it traveled). We documented additional introduction information, including whether the introduction of a species via a pathway was intentional or accidental.

### Assessing the extent and impact of invasive species

We have compiled information from over 350 data sources. The database now includes 329 marine invasive species, with at least one species documented in 194 ecoregions (84% of the world’s 232 marine ecoregions; Figure 1). The dominant groups of species in our database are crustaceans (59 species), mollusks (54), algae (46), fish (38), annelids (31), plants (19), and cnidarians (17).

We scored all 329 species for ecological impact and geographic extent. The mean ecological impact score was 2.55 (SD = 1.04) – halfway between “disrupts single species with little or no wider ecosystem impact” and “dis-

Panel 1. Threat scoring system

Each species in our assessment was assigned a score for each of the following categories (where data allowed), to indicate the magnitude of the threat it poses to native biodiversity. The scoring system was devised so that it could be applied consistently to different types of species and to those living in marine, freshwater, and terrestrial habitats.

#### Ecological impact

- **Invasive potential**
  - 4 – Currently/recently spreading rapidly (doubling in < 10 years) and/or high potential for future rapid spread
  - 3 – Currently/recently spreading less rapidly and/or potential for future less rapid spread
  - 2 – Established/present, but not currently spreading and high potential for future spread
  - 1 – Established/present, but not currently spreading and/or low potential for future spread
  - U – Unknown or not enough information to determine score

- **Geographic extent**
  - 4 – Multi-ecoregion
  - 3 – Ecoregion
  - 2 – Local ecosystem/sub-ecoregion
  - 1 – Single site
  - U – Unknown or not enough information to determine score

- **Management difficulty**
  - 4 – Irreversible and/or cannot be contained or controlled
  - 3 – Reversible with difficulty and/or can be controlled with significant ongoing management
  - 2 – Reversible with some difficulty and/or can be controlled with periodic management
  - 1 – Easily reversible, with no ongoing management necessary (eradication)
  - U – Unknown or not enough information to determine score
rupts multiple species, some wider ecosystem function”. Most species have been found in multiple ecoregions (mean geographic extent score of 3.98, SD = 0.19). We scored 324 species for invasive potential, with a mean score of 2.05 (SD = 1.03; “established/present...high potential for future spread”). The 268 species scored for management difficulty had a mean of 3.56 (SD = 0.71), indicating that most are difficult if not impossible to remove or control.

A primary driver for the development of this assessment was to provide a means of distinguishing relatively low-impact invasive species from those with potentially severe detrimental effects. We defined “harmful” invasive species as those having ecological impact scores of 3 or 4 (disrupting multiple species or wider ecosystems). Using this definition, 57% of species in our database are harmful, ranging from 47% of cnidarians to 84% of plants (Figure 2). The database also allows a geographic perspective; Figure 1 shows the number of harmful invasive species by ecoregion.

Our data reveal high levels of invasion in the following ecoregions: Northern California, including San Francisco Bay (n = 85 species, 66% of which are harmful), the Hawaiian Islands (73, 42%), the North Sea (73, 64%), and the Levantine Sea in the eastern Mediterranean (72, 50%). Realms that feature the highest degree of invasion are the Temperate Northern Atlantic (240, 57%), Temperate Northern Pacific (123, 63%), and Eastern Indo-Pacific (76, 45%). The least invaded realms are the Southern and Arctic Oceans (1, 100%, and 9, 56%, respectively).

We documented known or likely pathways for all 329 marine invasive species, with a mean of 2.0 pathways per species (SD = 1.1). More than 80% of species were introduced unin-
tentionally. The most common pathway for marine species in the database was shipping (ballast and/or fouling; 228 species, 57% of which are harmful). Of the 205 species with more detailed shipping pathway information, 39% are known to have been, or are likely to have been transported only by ship fouling, 31% are transported only by ballast, and 31% are transported by either ship fouling or ballast. The aquaculture industry is the next most common pathway (134 species, 64% of which are harmful; Figure 3).

To demonstrate regional variation, key pathways into the most heavily invaded ecoregions were determined by aggregating the known and likely pathways of species recorded in those ecoregions (Table 1). While shipping pathways are generally dominant, aquaculture is an important conduit for invasions on the west coast of the US, while the Suez Canal is a key pathway into the eastern Mediterranean.

Among the 359 data sources compiled to date, 47% are from peer-reviewed literature, 33% are from other published reports, 11% are from existing databases and atlases, and 3% are from unpublished reports (a list of database sources is provided in WebPanel 3). Most species were initially entered into our database using other databases and atlases, which, in almost every case, were compiled from the peer-reviewed literature and/or by regional experts. Additional information was obtained from the literature and reports. The accuracy of the patterns we found is dependent, in part, on the reliability of the data sources we used. Of course, even with reliable sources it is probable that, over time, corrections will be required. Necessary amendments may include incorporation of new studies or correction of errors from original field assessments, but environmental, evolutionary, or stochastic changes may also necessitate revision of the information in our database. For example, a heretofore benign, non-native species could invade a new niche and become a greater threat, or a native species could adapt to consume or out-compete an invader.

**Identifying research and information needs**

We documented more information on well-studied regions (e.g., US, Europe, Australia) than on other areas. Regions with a small number of invasions reported may contain few, if any, invasive species, but it is likely that at least some of these gaps are the result of a lack of research, monitoring, and/or public reporting of information.

A large number of ecological and economic impacts of alien species have been documented by others in regions identified as highly invaded on our map (e.g., San Francisco Bay, Cohen and Carlton 1998; Hawaiian Islands, Smith et al. 2003; North Sea, Eno et al. 1997; Mediterranean Sea, Galil 2006). It is probable that alien species are also affecting regions that appear, on our map, to be less invaded. To see if shipping data could act as a proxy indicator for identifying areas where invasions may have gone undetected, we compared our data on harmful species introduced via shipping in well-
studied regions (US excluding Alaska, temperate Europe, Australia, New Zealand) with separate shipping indicators (number of ports and shipping cargo volume) in a recent year (2003) by ecoregion (Halpern unpublished). We found statistically significant correlations between these shipping indicators and the number of harmful species reported (using a generalized linear model for these shipping indicators and the number of harmful species known to exist in places like the Mediterranean Sea (Mooney and Cleland 2001) and San Francisco Bay (Cohen and Carlton 1998) were excluded because impact information was not reported. These particular systems are already highly invaded, but a more complete assessment of impacts would improve understanding of their threat. The number of harmful species in each ecoregion provides an indication of the level of degradation from past invasions as well as, perhaps, the pressure from future invasions. This information could help policy makers to understand the trade-offs as they choose how to implement decisions and invest resources.

### Prioritizing pathways for prevention efforts

Identification of the most common pathways for introduction of harmful marine species (Figure 3) can inform and support international policies aimed at preventing such introductions. Our results, based on the largest dataset compiled to date, clearly confirm earlier studies (eg Ruiz et al. 1997; Minton et al. 2005) and point to shipping as a major global pathway. This provides a powerful, objective argument in support of ongoing efforts to improve ballast water management practices (eg International Maritime Organization’s Ballast Water Convention and Management Programme; http://global-ballast IMO.org). Even so, the major impacts of ship fouling species suggest that ballast water agreements alone may be insufficient. We also confirm earlier studies describing the role of aquaculture operations in marine invasions (eg Naylor et al. 2001). Stricter, industry-wide control measures could be developed and legal and enforcement structures strengthened to restrict intentional and accidental introductions of harmful species.

Our assessment data can also be used by policy makers in specific regions (Table 1). For example, in the two ecoregions that extend along the coastlines of Oregon and Washington State, including the Puget Sound, aquaculture has been the most common pathway for introduction (71% of non-native marine species documented in likely effects in other regions where those species are found. We are making our database freely available online, to encourage further submissions; this will improve reporting and refine our knowledge of global invasion patterns.

### Conservation and policy applications

Using data collected in this assessment, we can identify global patterns and draw preliminary conclusions that may be applied to conservation and policy efforts. Here, we discuss several ways in which our database could be used to inform policy decisions.
these ecoregions were introduced by aquaculture). Most of these introductions probably occurred accidentally, through oyster farming (with introduced species hitchhiking on shells or equipment). Of the 33 species known to be associated with oyster farming, 55% are harmful, and most are difficult if not impossible to remove or control (26 of 28 species scored for management difficulty received a score of 3 or 4). In this region, policy makers, conservation practitioners, and the aquaculture industry should continue to work together to prevent any future invasions, by improving practices and perhaps limiting new operations.

Our data could inform biosecurity measures by helping to identify species that have not yet invaded an ecoregion or realm but have had considerable impact in similar habitats elsewhere. Our use of biogeographic units will be of value in identifying “similar” vulnerable ecoregions, and more refined data about ship movements and habitat suitability would further support such work (see Hayes et al. 2002).

**Informing introduction decisions**

Species are often introduced to new habitats for their economic benefits or to meet development needs (e.g., aquaculture). There may be an initial economic gain, but if a species becomes invasive, it can cause serious, unforeseen economic and ecological damage. These risks of invasion have often not been factored into decisions on species introductions (Naylor et al. 2001).

Our impact scores offer guidance on the merits of these intentional introductions. For example, oysters have been deliberately introduced into coastal waters worldwide, to be cultured for food. One species in particular, *Crassostrea gigas*, has been introduced in at least 45 ecoregions (Figure 4). Its high ecological impact score (3) should cause decision makers and regulators to reconsider plans for introduction of this oyster into new areas. While its harvest brings economic gains, the ecological impact of introductions of this species are potentially dramatic. Oysters play a role in many estuarine ecosystem processes; altering their abundance or distribution causes complex changes. Furthermore, when oyster populations are supplemented with alien oysters, other alien species can piggyback on their shells (Ruesink et al. 2005). Global information about distribution and impacts could inform risk assessments and decisions about whether, and how, species should be introduced in the future.

**Conclusions**

The new invasive species database provides a powerful tool for understanding the patterns and processes of marine invasions. The current data holdings already represent the most comprehensive collection of information on marine invasions worldwide. By quantifying impacts and describing pathways of invasion, our data framework improves our ability to assess threats and impacts and allows valid and consistent assessments between locations, habitats, or taxonomic groups. Work is continuing to expand this assessment of marine invasive species and similar analyses are underway for terrestrial and freshwater species.

Initial findings confirm earlier studies and point to shipping and aquaculture as the most critical pathways for marine invasions globally. At the same time, regional differences in dominant pathways are highlighted.

The information we have compiled can begin to inform the large-scale strategies necessary to prevent future introductions. This global perspective allows researchers and regulators to better consider where and how invasive species are likely to be introduced and invade in the future. This can help to inform risk assessments and decisions about potential future introductions, as well as the development of species- and pathway-specific regulations and geographically targeted policies.

We have also identified some disparities in information resources on marine invasive species. In particular, there is clearly under-reporting of both microorganisms and low-impact invasive species, and there appears to be a geographic gap in our knowledge regarding large parts of east Asia, where invasions are highly likely, but little published information exists. We hope that these observations may catalyze and encourage efforts to make decentralized data available and direct future research efforts.
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References

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Introduction to the Topic Forum Discussion Paper

The attached topic forum discussion paper is one of five papers designed to provoke and inspire enduring community conversation and critical thinking about the specific problems facing Puget Sound, and the strategies and actions needed to overcome the threats we face. These papers are being used to help create the 2020 Action Agenda. Background on the topic forum process and how this information is being used can be found on our website at www.psp.wa.gov in the Action Agenda Center.

The papers represent the first effort in our region to comprehensively synthesize and document what we know about the Sound’s problems, solutions that work, our current approach to solving problems, and what approaches we need to continue, add, or change. These papers address broad science and policy questions, providing an overview of each topic that looks at Puget Sound ecosystem from the crest of the Cascades to the Strait of Juan de Fuca, and documenting the basis of our conclusions and recommendations. They are fundamental to establishing strong connections between science and policy as we develop the 2020 Action Agenda.

The Partnership asked small groups of science and policy experts to prepare each of the draft discussion papers as a starting point. The authors were instructed to rely on readily available existing information and provide a high-level overview of the key issues pertaining to each topic. The draft papers were reviewed by a broad audience, and were discussed at individual topic forums held in April and May. More than 500 people attended the topic forums, and dozens more provided comments online. During the review period, over 1,200 pages of public comment from were received from 229 people or entities. The Partnership, in conjunction with the papers’ authors, reviewed and considered all of the comments as we prepared these revised discussion papers. Summarized comments and responses are included as appendices to the papers. A complete set of comments will also be posted on the Partnership's webpage.

The discussion papers are intended to be concise and as brief as possible, providing a synthesis of existing readily available information and an initial list of recommendations for moving forward to achieve the Partnership’s six main goals. Work to integrate the products from the respective topic forums within an ecosystem management framework is ongoing, and will be used to support the Action Agenda. In reading the revised discussion papers, several concepts should be considered:

- **The discussion papers provide an overview of the topic**, summarizing and synthesizing existing documentation. These papers are intended to provide a framework for future management strategies, but are not intended to address in detail all available data on the topic.

- **The Partnership will be identifying priority actions that are based on science.** There is currently a wide range of opinion about the Sound’s problems and literally hundreds of ideas for how to solve them. This was evidenced by the broad range of opinions expressed during the topic forum process. Our goal is to find reasonable consensus on the general nature and magnitude of the documented threats to Puget Sound, so that we have a better chance of prioritizing durable and effective solutions.

- **The papers mainly focus on the Sound as a whole.** We know that there are variations in information availability, type and extent of threats, and workable solutions in different parts of our region. The action area profiles that we are also preparing will help highlight local issues.

- **The papers are organized to logically step through three initial questions (two are science and one is policy) that build to a rational conclusion (the fourth question) about the strategies and actions that we will need continue, add, or change as a region.** The design is intentional so that 1) our policies are based on science and 2) scientists and policy experts talk to one another.
• The discussion papers will be used to develop cross-topic priorities for the Action Agenda. A number of key themes emerged from the topic forum process, which are being used to help define priorities for management strategies.

• The intent of papers is to focus on WHAT the problem is and WHAT solutions are needed, rather than HOW to implement specific solutions. The Partnership will identify “how” with those who have to implement the solutions.

• The recommendations to the Partnership in the papers represent the conclusion of the authors based on their expertise and comments received. The recommendations will be considered by the Partnership, but should not be interpreted as a Partnership endorsement. This is an intentional design of the topic forum process.

• The papers intentionally do not focus on the need for more education/outreach, new funding strategies including creative incentives, and a coordinated monitoring and adaptive management program. The Partnership knows that these three aspects are critical to long-term success and is using other processes to address them. That work is linked to the development of the Action Agenda. By addressing the system-wide needs, we will be able to more effectively focus the education/outreach, funding, and adaptive management and monitoring strategies.

• A Partnership Quality of Life topic paper is being prepared to follow the other five topic forum papers and pull together human well-being information from each.

• The Partnership Science Panel will review the papers with a specific focus on how well the responses to the two science questions capture current understanding of the topic and key areas of uncertainty. This review is intended to help develop a targeted scientific research program.

The Partnership greatly appreciates the level of interest and participation that reviewers have shown by attending topic forums and providing thorough, thoughtful comments. The comments that we received have greatly expanded and deepened the overall level of discussion, and moved our knowledge forward on these topics. We are committed to continuing this level of engagement.
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Preface

This discussion paper was available for public review in April 2008. The paper was intended to serve as an overview of the species, biodiversity and food web in Puget Sound, and to provide background discussion for the topic forum workshop, which was held on May 1, 2008. More than 80 people attended the workshop. Numerous comments were received on this topic; summarized comments and their responses are included as an appendix to this document. Many comments were received requesting additional detailed information on a variety of issues and concerns. Because the topic forum paper is intended to be an overview of the topic, providing a framework for management priorities, the paper has not been substantially revised to provide additional detail. Such refinement will occur through several ongoing efforts conducted by the Partnership; concepts presented in this paper will be built upon during ongoing and future Partnership efforts. The discussion paper has been revised to incorporate new information that was introduced through the topic forum process, resulting in a more comprehensive assessment of the issue.

This discussion paper provides a broad overview of scientific literature that describes the status of and threats to biodiversity, species, and the food webs in the Puget Sound basin, and the effectiveness of management approaches designed to ameliorate those threats. The paper also describes the approaches that a wide variety of organizations are taking to protect species, biodiversity, and the food webs, and identifies new priorities for action. The Puget Sound Partnership will refine these priorities, and the framework presented here, in future phases of Action Agenda development.
Science Question 1 (S1): Status of Species, Biodiversity, and the Food Web in Puget Sound

The Puget Sound basin, with its varied terrestrial, freshwater, and marine habitats, is a highly productive and diverse ecosystem. The Sound’s waters support numerous residential and migratory marine species, including over 150 species of marine birds, 230 species of fish, 20 mammal species, over a thousand species of plants and algae, and numerous invertebrates and microbes.1 Upland species, including mammals, reptiles and amphibians, birds, fish, invertebrates, plants, and microbes, also play an important role in the ecosystem.2 Individually and taken as a whole, the flora and fauna of the Puget Sound region contribute extensively to its uniqueness and the ecological, economic and cultural values held by the Puget Sound community.

This section of the discussion paper provides a broad overview of the scientific literature describing the status of and threats to species, biodiversity, and the food webs in the Puget Sound basin.

Key Findings from Previous Efforts

A. Abundance, productivity, spatial distribution, and diversity of key species

The Puget Sound basin is home to a wide diversity of species that depend upon marine, estuarine, freshwater, and terrestrial environments. Given this biodiversity, it is challenging to select “key” species. The National Oceanic and Atmospheric Administration (NOAA) is leading work to develop indicators for Puget Sound, including a list of indicator species. However, at the time of development of this paper, that work is incomplete. Therefore, in this section we discuss the abundance, productivity, spatial distribution, and diversity of three species generally acknowledged to be “key” indicator species in the Puget Sound basin: Chinook salmon, Pacific herring, and golden paintbrush. Pacific herring are a fundamental part of the marine food web, while Chinook salmon are a key species in the marine and freshwater food webs. Golden paintbrush is often used as an indicator of the health of prairie habitat in the Puget Sound lowlands. Chinook salmon and golden paintbrush are both listed as threatened species under the Endangered Species Act.

Examining the abundance, productivity, spatial distribution, and diversity of key species can be valuable because key species can serve as indicators of the health of the Puget Sound ecosystem. These four characteristics of species populations reflect important determinants of their health and sustainability, and are considered necessary to a full description of their status.3

It is important to state clearly here that the discussion below is possible because Chinook salmon, Pacific herring, and golden paintbrush are well-studied species in the Puget Sound basin. While detailed information is usually available in recovery plans for listed species, such data are not available for hundreds, if not thousands, of other native and non-native species known to inhabit the basin.

Chinook salmon (*Oncorhynchus tshawytscha*)

The Puget Sound Salmon Recovery Plan4 summarizes information on abundance, productivity, spatial structure, and diversity for Puget Sound Chinook salmon. The information in this section is drawn from that Plan.

**Spatial Structure:** The Puget Sound Technical Recovery Team analyzed Chinook salmon data and identified 22 independent populations of Chinook in Puget Sound. These populations are distributed around the Sound. The Elwha and Dungeness populations border the Strait of Juan de Fuca, while the Skokomish and Mid-Hood Canal populations return to the Hood Canal. Eastern Puget Sound boasts 18 independent populations, ranging from the Nooksack populations in the north to the Nisqually in the south. Scientists estimate that historically there were 30 to 37 populations of Chinook in Puget Sound.
Diversity: The Puget Sound Technical Recovery Team also summarized information about genetic diversity among Chinook, and identified six major genetic clusters of Chinook salmon in Puget Sound, as follows:

1. Strait of Juan de Fuca Chinook salmon
2. Nooksack River early-returning Chinook salmon
3. Skagit and North Fork Stillaguamish Rivers Chinook salmon
4. Snohomish and South Fork Stillaguamish Rivers Chinook salmon
5. Central and southern Puget Sound and Hood Canal late-returning Chinook salmon
6. White River early-returning Chinook salmon

Puget Sound Chinook have lost some of their historic genetic diversity as a result of the loss of 8 to 15 populations. Many of these lost populations were early-returning runs. In addition, hatchery fish heavily influence the genetic structure of several populations.

Abundance and Productivity: Table S1-1, reproduced from the Recovery Plan, shows recent abundance and productivity data for the 22 populations of Chinook salmon in Puget Sound. Abundance in this table is defined as the geometric mean of naturally spawning Chinook populations. The productivity estimates are the number of adult offspring that return and spawn successfully from a single parent spawner. A productivity estimate of 1.0 means that the population is replacing itself; productivity estimates less than 1.0 are in purple italics. Productivity estimates were not available for 2000-2004.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geometric Mean</td>
<td>% Hatchery Contribution</td>
<td>Productivity</td>
</tr>
<tr>
<td>North + Middle Fork Nooksack</td>
<td>140</td>
<td>21%</td>
<td>1.29</td>
</tr>
<tr>
<td>South Fork Nooksack</td>
<td>243</td>
<td>7%</td>
<td>0.60</td>
</tr>
<tr>
<td>Lower Skagit</td>
<td>2,732</td>
<td>1%</td>
<td>0.59</td>
</tr>
<tr>
<td>Upper Skagit</td>
<td>8,020</td>
<td>2%</td>
<td>0.69</td>
</tr>
<tr>
<td>Upper Cascade</td>
<td>226</td>
<td>0%</td>
<td>0.68</td>
</tr>
<tr>
<td>Lower Sauk</td>
<td>888</td>
<td>0%</td>
<td>0.61</td>
</tr>
<tr>
<td>Upper Sauk</td>
<td>720</td>
<td>0%</td>
<td>0.57</td>
</tr>
<tr>
<td>Suattle</td>
<td>687</td>
<td>0%</td>
<td>0.40</td>
</tr>
<tr>
<td>North Fork Stillaguamish</td>
<td>669</td>
<td>0%</td>
<td>0.92</td>
</tr>
<tr>
<td>South Fork Stillaguamish</td>
<td>257</td>
<td>0%</td>
<td>1.31</td>
</tr>
<tr>
<td>Skykomish</td>
<td>3,204</td>
<td>14%</td>
<td>0.52</td>
</tr>
<tr>
<td>Snoqualmie</td>
<td>907</td>
<td>12%</td>
<td>1.23</td>
</tr>
<tr>
<td>Sammamish</td>
<td>388</td>
<td>41%</td>
<td>0.28</td>
</tr>
<tr>
<td>Cedar</td>
<td>733</td>
<td>9%</td>
<td>0.51</td>
</tr>
<tr>
<td>Green/ Duwamish</td>
<td>7,966</td>
<td>62%</td>
<td>0.50</td>
</tr>
<tr>
<td>White</td>
<td>73</td>
<td>56%</td>
<td>7.51</td>
</tr>
<tr>
<td>Puyallup</td>
<td>1,509</td>
<td>15%</td>
<td>1.86</td>
</tr>
<tr>
<td>Nesqually</td>
<td>602</td>
<td>3%</td>
<td>4.22</td>
</tr>
<tr>
<td>Skokomish</td>
<td>1,030</td>
<td>69%</td>
<td>0.49</td>
</tr>
<tr>
<td>Mid Hood Canal</td>
<td>87</td>
<td>26%</td>
<td>1.41</td>
</tr>
<tr>
<td>Dungeness</td>
<td>185</td>
<td>83%</td>
<td>0.12</td>
</tr>
<tr>
<td>Elwha Nat Spawners</td>
<td>2,055</td>
<td>34%</td>
<td>0.46</td>
</tr>
<tr>
<td>Elwha Nat+Hat Spawners</td>
<td>3,087</td>
<td>34%</td>
<td>0.67</td>
</tr>
</tbody>
</table>
As the table shows, abundance of Chinook varies substantially by population. The Upper Skagit and Green/Duwamish populations were the only two that have had average runs exceed 10,000 spawners in recent years. Other populations have experienced critically low abundance in the last 20 years, such as the Nooksack, Sammamish, Cedar, Dungeness, South Fork Stillaguamish and Mid-Hood Canal populations. It is also important to note that of the 12 populations that exceeded 1,000 natural spawners between 2000 and 2004, only the two Skagit populations are believed to have a low percentage (less than 5%) of hatchery fish spawning naturally. The other 10 rely more on hatchery fish that spawn in the wild.

In 2003, the National Marine Fisheries Service calculated the long term productivity trend for naturally spawning populations, and found that the trend was flat. This finding is an improvement over the trend calculated in 1998, which showed productivity declining by 1.1 percent. However, the presence of hatchery fish on the spawning grounds complicates these calculations.

**Summary:** Given these data, the Puget Sound Salmon Recovery Plan concludes that few Puget Sound Chinook salmon populations are viable currently. Scientists estimate that populations of salmon with high percentages of natural spawners are concentrated in the Skagit and Stillaguamish River basins, which is a significant reduction in spatial structure compared to historic conditions. As noted previously, Puget Sound has lost several populations of early-run Chinook, decreasing the species’ genetic diversity. Except for the Skagit system, all populations are at a small fraction of their historical abundance, and the productivity of many populations is below replacement value or declining.

**Pacific Herring (Clupea pallasi)**

The 2007 Puget Sound Update: Ninth Report of the Puget Sound Assessment and Monitoring Program summarizes information about the spatial structure, diversity, and abundance of Pacific herring. The information in this section is drawn from that report, unless otherwise noted.

**Spatial Structure:** Pacific herring spawn in 19 areas of Puget Sound. These spawning grounds are fairly well dispersed around the Sound, with locations in Whatcom, Skagit, San Juan, Island, Snohomish, King, Thurston, Jefferson, Mason, Kitsap, and Clallam Counties. The 2007 Puget Sound Update groups these stocks into three categories: Straits, South/Central, and North.

**Genetic Diversity:** Based on timing and location of spawning activity, the Washington Department of Fish and Wildlife (WDFW) has identified 19 stocks of Pacific herring. According to the WDFW Forage Fish website, other stock-specific features, such as pre-spawner holding area behavior, unique age structures, and distinctive spawning timing, support the geographically-based stock definitions. The Cherry Point stock is genetically distinct from other Puget Sound and British Columbia herring stocks.

**Abundance and Productivity:** In 2002, the total abundance of Pacific herring in Puget Sound reached a (recent) peak of 17,700 tons. The biomass of the south/central Puget Sound stocks, which increased between 1997 and 2002, drove this peak. The northern herring stocks have remained at lower abundance levels, primarily due to the critical status of the Cherry Point herring stock. The Cherry Point herring stock has varied over time from about 3,000 tons to almost 15,000 tons between 1973 and 1995. In 2000 the stock reached a low of only 808 tons, but had risen to about 2,000 tons in 2005.

The Strait of Juan de Fuca stocks also have low abundance. In particular, the Discovery Bay stock has decreased significantly and steadily since reaching a high of 3,200 tons in 1980, and now averages between 200 and 250 tons annually. Similarly, the Dungeness/Sequim Bay stock has very low abundance.

No estimates of the productivity of Pacific herring stocks were found in the course of the literature review undertaken for this project.
**Summary:** Most Pacific herring stocks in Puget Sound declined between 2000 and 2005. The northern and Straits stocks exhibit a long-term decline, while the central and south Sound stock declines are part of a variable trend of stock increases and decreases.

**Golden Paintbrush (*Castilleja levisecta)*

The United States Fish and Wildlife Service finalized the recovery plan\(^7\) for this prairie plant in 2000. The information in this section is drawn from that plan and from the subsequent Five-year Review (2008).

**Spatial Structure:** Golden paintbrush populations exist in Washington and British Columbia. Eleven known populations remain, of which nine are in Washington. All nine of these populations are in the Puget Sound basin. There are five populations in Island County, three in San Juan County, and one in Thurston County. Historically, the species was reported from more than 30 sites in the Puget Sound region (including British Columbia) and extending as far south as the Willamette Valley of Oregon. The species was last observed in 1937 in Oregon and is presumed extirpated from Oregon.

**Diversity:** Because most of the remaining golden paintbrush populations are small – both in terms of numbers of individuals and area covered by the population – they are vulnerable to demographic events.

**Abundance and Productivity:** Table S1-2 contains population information from the Five-year Review (2008)\(^8\) for the nine remaining populations of golden paintbrush found in Puget Sound. As the table shows, just three of the populations have more than 1,000 individual plants, which is the recovery threshold for the species. Most populations are much smaller. The population trend is increasing at just two locations, where grassland management has been ongoing. The other populations are declining, stable, or unknown.

**Table S1-2: Abundance and Productivity of Golden Paintbrush Populations in the Puget Sound Basin**

<table>
<thead>
<tr>
<th>Site Name</th>
<th>County</th>
<th>Population Size</th>
<th>Year</th>
<th>Area</th>
<th>10-Year Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocky Prairie Natural Area Preserve (NAP)</td>
<td>Thurston</td>
<td>&gt;9,000</td>
<td>2008</td>
<td>ca. 12 acres</td>
<td>stable</td>
</tr>
<tr>
<td>Naas/Admiralty Inlet NAP</td>
<td>Island</td>
<td>145</td>
<td>2008</td>
<td>ca. 1 acre</td>
<td>stable</td>
</tr>
<tr>
<td>Fort Casey State Park</td>
<td>Island</td>
<td>1,700</td>
<td>2008</td>
<td>&lt;1 acre</td>
<td>increasing</td>
</tr>
<tr>
<td>West Beach</td>
<td>Island</td>
<td>97</td>
<td>2008</td>
<td>&lt;1 acre</td>
<td>declining</td>
</tr>
<tr>
<td>Forbes Point</td>
<td>Island</td>
<td>247</td>
<td>2008</td>
<td>&lt;1 acre</td>
<td>stable</td>
</tr>
<tr>
<td>Ebey’s Landing</td>
<td>Island</td>
<td>601</td>
<td>2008</td>
<td>ca. 1 acre</td>
<td>declining</td>
</tr>
<tr>
<td>False Bay</td>
<td>San Juan</td>
<td>495</td>
<td>2008</td>
<td>&lt;1 acre</td>
<td>increasing</td>
</tr>
<tr>
<td>Davis Point</td>
<td>San Juan</td>
<td>0</td>
<td>1998</td>
<td>&lt;1 acre</td>
<td>presumed extirpated</td>
</tr>
<tr>
<td>San Juan Valley</td>
<td>San Juan</td>
<td>&gt;5,000</td>
<td>2003</td>
<td>1 acre</td>
<td>last monitored in 2003 - unknown</td>
</tr>
<tr>
<td>Long Island</td>
<td>San Juan</td>
<td>154</td>
<td>2002</td>
<td>&lt;1 acre</td>
<td>unknown</td>
</tr>
</tbody>
</table>

**Summary:** The spatial distribution of golden paintbrush is significantly reduced from its historical range. Only three of the nine known populations in the Puget Sound basin meet or exceed the recovery threshold of 1,000 individuals.

It is important to reiterate here that while there is general agreement that the three species discussed in this section are important as indicators of their food webs and habitats, they are not the only species that can be considered “key” to the ecology of the Puget Sound basin. We have chosen to discuss these species partly due to the agreement on their significance, but also partly because data exist about them. Similar data do not exist for hundreds, if not thousands, of species in the basin. In many instances, assessment information about individual species exists for one or more of the four status attributes, but scientists and managers have not determined the levels of abundance,
productivity, spatial structure, or diversity that are sufficient to meet ecosystem goals. In other words, for most species, answering the question of ‘how much’ of any of those attributes are required for a certain level of ecosystem performance or function usually has not been addressed.

The abundance, productivity, spatial structure, and diversity information described above for these key species illustrates how this information can be useful. For Chinook salmon, scientists have used the information to determine whether the populations are viable or not. Managers can use it to determine whether recovery goals have been met. In addition, comparing this information to historical conditions imparts a sense of the scale of the changes in populations of these key species, two of which form crucial links in Puget Sound food webs and one of which serves as an indicator of the loss of an entire ecosystem (prairie or grassland). And, of course, tracking this information over time provides trend data. All three of these key species are in decline.

Assessing and reporting the status of individual species typically focuses on that species’ persistence, and not how the abundance, productivity, spatial structure and diversity relate to other ecosystem roles that species can play, such as providing food, predation, competitive interactions, habitat structure, or nutrients to food webs. For example, the recovery goals for Chinook salmon in Puget Sound were developed based on modeled estimates of how many salmon would be needed for each population so that it would persist into the future and be able to sustain desired levels of commercial and recreational harvest. The recovery goals did not specify how many salmon would be needed to meet other ecosystem needs, such as providing food for orcas or marine-derived nutrients to riparian communities in watersheds where salmon spawn and decomposing carcasses are an important nutrient source.

B. Food web status

Puget Sound does not have one food web. Rather, there are many food webs in the Puget Sound basin, ranging from marine to estuarine to freshwater aquatic to terrestrial. Within each of these four categories, there are many smaller food webs (or food chains). It is important to note that the marine, estuarine, freshwater, and upland food webs are not discrete and independent, but rather are strongly linked by “organic matter sources, physical proximity, exchange of water, and organisms that change habitats during the course of their life cycles.”

Food webs also vary spatially and temporally, and some species occupy multiple places or serve multiple purposes in the food webs.

An excellent example of these phenomena is Chinook salmon, which link all four major food web categories (marine to upland) and occupy multiple roles in these food webs depending on their life history stages.

Other than descriptive studies of nearshore food web linkages and structure in northern Puget Sound and the eastern Strait of Juan de Fuca, and preliminary investigations of food web sources using biogeochemical tracers, our understanding of marine and estuarine food webs is limited to target consumers (e.g., juvenile salmon in estuarine and nearshore Puget Sound environments). Recent work modeling historic shifts in food web structure in Puget Sound and establishing baseline conditions and indicators among the Sound’s fishes gives us a slightly better understanding of the marine and estuarine food webs. The Sound Science report presents a highly readable description of what is known about the Puget Sound food webs, providing general information about primary producers, herbivores and detritivores (including benthic infauna), mid-level consumers and top-level predators. However, fundamental data are still needed about many basic elements of the marine and estuarine food webs, such as phytoplankton and zooplankton productivity.

Even though our understanding of the marine and estuarine food webs is limited, there are many indications that the food webs have changed significantly from historical conditions. As described above, populations of Pacific herring and Chinook salmon are dramatically reduced from their historic abundance levels, and early runs of Chinook salmon have been lost. A model of changes in the South Puget Sound food web between 1970 and 1999 showed that the biomass of dabbling ducks, diving ducks, dogfish, flatfishes, hake, resident coho salmon, herring, lingcod, loons and grebes, Pacific cod, pollock, rockfishes, and skates and rays had declined during that interval. Assemblages of marine birds and waterfowl differ along an urban shoreline gradient progressing from more to less urbanized in Puget Sound. Harvest practices may have shifted species and population dynamics, for example by preferentially removing adult individuals, thus affecting food web dynamics. Tideflats, critical areas for energy exchange through
transfer of nutrients and sunlight, have been altered dramatically, and the increase in human population around the Sound has heightened the input of nutrients to the Sound.\(^9\)

We were not able to locate summaries of the status of the terrestrial and freshwater aquatic food webs of the Puget Sound basin. However, the lack of studies indicates that our knowledge of the health of terrestrial and aquatic food webs of this region is limited, similar to our knowledge of the marine and estuarine food webs. Also similar to the marine environment, there are indications that the terrestrial food webs have changed significantly from historical conditions. The *King County Biodiversity Report 2008*, for example, discusses the fact that urbanization and various forms of development have altered the lowland areas of the county severely.\(^18\) These habitat changes in the lowlands, and the changes in species composition that accompany them, are likely to have altered the terrestrial and freshwater food webs there.

In summary, although we have some data about individual species in the Puget Sound food webs, and can illustrate links between some species of cultural or economic importance, there is no assessment of the condition or functioning of the Puget Sound food webs. However, our knowledge that many species are declining in abundance and/or productivity strongly suggests that the food webs have been altered significantly from historical conditions.

### C. Status of biodiversity

Puget Sound hosts a wide variety and number of species and communities, some rare, others common. This biodiversity is threatened by declines in the abundance and productivity of many species. As of 2008, 21 species in the region were listed by the federal and/or state government(s) as threatened or endangered (see Response to Question P1). Several species, such as Chinook salmon and Lake Washington kokanee, have disappeared from parts of their historical ranges.\(^4,19\) Others, such as western pond turtles, have disappeared from the Puget Sound region entirely.\(^20\) The Tacoma pocket gopher is globally extinct.\(^21\)

Assessments of Puget Sound biodiversity are rare, with perhaps the most prominent being the Puget Sound Ecoregional Assessment prepared by The Nature Conservancy and partners.\(^22\) This work highlights areas of the Sound that are understood to both support significant biodiversity and to be vulnerable; due to limitations on data for marine biodiversity, this work focuses on upland areas. (See sample map of priority landscapes in Appendix 2.) The Washington Biodiversity Council found that Washington “has experienced a dramatic loss of its native biodiversity over the last 100 years and faces significant threats in the future.”\(^23\)

The *King County Biodiversity Report 2008* characterizes biodiversity in that county as moderately healthy, noting that while some habitats have been dramatically altered, others remain largely intact. Some habitats and species in the county are declining, while others show signs of recovery.\(^18\) The fact that biodiversity can be characterized as moderately healthy in the most populous county in the state is a hopeful sign for biodiversity in the Puget Sound basin.

### D. Deficiencies in our current knowledge

As the foregoing suggests, there are significant gaps in our current knowledge of species, the Puget Sound food webs, and biodiversity.

**Species:** Nothing is known about the abundance, productivity, distribution, and diversity of thousands of Puget Sound species. In addition, there are very few analyses of what levels of abundance, productivity, spatial structure, or diversity are necessary for certain ecosystem functions, such as population persistence or provision of food for other species. As a result, we cannot gauge the health or status of these species. Others have been extensively studied, in most cases due to their cultural or commercial importance, and of these cases we know enough to show that many are declining.\(^5\) Yet there are still gaps in our knowledge of well-studied species such as the orca or salmon, as well as our knowledge of the connections between species. Little is known about early life history stages of many species, even those for which there is good information about adults.
Food Webs: Our knowledge of food webs in the Puget Sound basin is centered primarily on species of cultural or economic importance. We know that the food webs are very complex, with complicated linkages between species, but do not know enough about these linkages to understand the effects of human actions on the food webs.9 We also lack basic data, such as the primary productivity of Puget Sound’s marine areas, or the food webs for terrestrial birds.24 Lastly, we lack the data to assess the health of the Puget Sound food webs.

Biodiversity: Very little is known about the biodiversity of Puget Sound’s marine environment, particularly the deep water zones.

Several recent reports have characterized the major areas needing further research, including:

- Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8 and 9).25
- Species recovery plans for listed species including Southern Resident killer whales,26 Puget Sound Chinook salmon,4 Hood Canal summer-run chum salmon,27 marbled murrelets,28 and golden paintbrush.7
- Puget Sound Update reports issued periodically (e.g., see Reference 5).

These reports identify several common areas in which more effort is needed to recover declining species and protect biodiversity and the food webs:

- Identify the most immediate needs for species conservation and recovery, whether identifying the most pressing threats to Hood Canal summer chum survival,27 or the status, distribution, and function of unclassified microbes, fungi, invertebrates, and fishes.1,5,23 As mentioned previously, little is known about the abundance, productivity, spatial structure, and diversity of thousands of species in the Puget Sound basin. Finally, without analyses of “how much is enough” for species-status attributes, it is difficult to set goals and design strategies to achieve them.

- Improve our understanding of the Puget Sound food webs, such as rates of transfer between levels of food chains, and whether and when the net community metabolism changes from being autotrophic to heterotrophic.29 Developing this understanding will be critical to our ability to predict the effects of human actions on the food webs, which can change rapidly in response to our activity.9

- Develop appropriate frameworks to assess and manage biodiversity, whether through using the index of biological integrity (IBI) approach or developing a comprehensive habitat map of the seafloor.22

Threats to Species, Biodiversity, and Food Web Status in Puget Sound

A. Documented threats to abundance, productivity, spatial distribution of key species

There is general agreement that habitat alteration, climate change, impacts to surface and groundwater quantity, pollution, harvest, cultured species, and invasive species all threaten native species, food web status, and biodiversity.1 There are both anthropogenic and natural drivers of these threats, described by one author as climate, ocean conditions, the global economy, scarcity of and competition for natural resources, human population growth, and lifestyle preferences.31 These threats may act synergistically, and there is great uncertainty regarding the degree to which stressors most affect a given population, or which are the most important to address for recovery.26

Forces outside Puget Sound’s borders, such as runoff from the Fraser River, changes to migratory birds’ breeding and wintering grounds, or airborne mercury particles originating in Asia,1,5 are important but are not considered in detail here. In addition, the limits of our understanding of species’ life characteristics, the interactions between
species, and the nature of the threats they face, all can hamper our management of, and so threaten, Puget Sound species, food webs, and biodiversity.

**Habitat Alteration**
Conversion and modification of marine, estuarine, and upland ecosystems have reduced habitat for Puget Sound species. Port development, beach armoring, and other shoreline modifications have changed the nature of one-third of all Puget Sound shorelines, with major modifications to estuaries such as the Duwamish. Beach modification threatens critical spawning habitat for surf smelt and Pacific sand lance. Population growth and suburban sprawl have accelerated the fragmentation of upland habitat, as forests, prairies, and wetlands are converted to homes, businesses, and roads. Habitat fragmentation leads to the loss of habitat and wildlife corridors, and as areas are paved over and forest patches grow smaller, can lead to decreases in the biodiversity of freshwater benthic fauna and birds. Agriculture has also modified wetland and forest habitats essential to many species’ survival. (Please see the Land Use/Habitat Protection and Restoration Topic Forum Discussion Paper for more information about habitat alteration.)

**Climate Change**
Sea level rise associated with climate change is expected to increase erosion and landslides and to decrease estuarine habitat. Changes in oceanographic processes such as circulation, mixing, and stratification, as well as water temperatures and chemistry, are expected to influence salmonids and other marine life. Increases in marine water temperatures may affect plankton diversity, distribution, and abundance, driving changes in other species’ composition and abundance in the marine food webs. Climate change and higher temperatures may already be limiting populations of Pacific cod. Changes in early spring temperatures are expected to lead to mismatches in insect development and host plant flowering, affecting the reproductive success of the populations and possibly leading to extinctions. Warmer air temperatures apparently have led to a lengthening of the period of summer stratification in Lake Washington, which in turn affects the timing of phytoplankton and zooplankton blooms, disrupting the interaction between predator and prey at the base of the food chain. While there are uncertainties related to the amounts of future emissions that will affect climate change, and the climate system’s sensitivity to changes in emissions, scientists project that climate change will have significant effects on the species, food webs, and biodiversity of the Puget Sound basin.

**Surface / Groundwater Impacts**
Freshwater inputs from rivers and creeks, and groundwater seepage from banks and bluffs, are important habitat-forming processes in the nearshore. Low streamflows and stormwater peak flows affect many rivers and streams in the Puget Sound region. The lack of sufficient streamflows during key spawning times, combined with high water flows that degrade critical spawning habitats, limits the recovery of threatened salmon species in several river basins in Puget Sound. Given the hypothesis that Puget Sound’s human population will increase significantly in the coming decades, balancing the water needs of fish populations and humans will likely be increasingly difficult. (Please see the Water Quantity Topic Forum Discussion Paper for more information about this topic.)

**Pollution**
Human activities on the shores of Puget Sound and in industrial centers across the globe contribute metals, toxins, nutrients, pathogens, and xenobiotics (chemicals found in organisms but not expected to be produced by or present in them) to the Sound. These contaminants make their way into biota in the Puget Sound basin via a number of pathways including stormwater, point-source and non-point-source discharges with potentially serious results. Pesticides applied to oyster growing areas affect the ability of anadromous cutthroat trout to swim effectively, and trout exposed to these pesticides suffered higher rates of predation from lingcod. Nutrients in wastewater and in runoff can lead to toxic algal blooms or to closures of shellfish growing areas. Eutrophication, or low oxygen levels due to increased nutrient loading, can cause direct mortalities of marine fish species. Toxic chemicals in stormwater can adversely affect fish health, and non-point-source pollution can degrade the biological integrity of the aquatic communities that support productive fish populations. Contaminants in stormwater have led to an increase in
pre-spawn mortality among coho in urban streams in Puget Sound. Concentrations of PBDE (flame retardants) in Puget Sound harbor seals have risen 1,500 percent since 1984, and are now twice as high as the concentrations of PBDE in harbor seals from the Strait of Georgia. Total concentrations of PCBs in Puget Sound herring stocks are four to nine times higher than those in Georgia Basin stocks. Accumulation of these and other toxins in the food web is thought to be a major driver in the declining health and reproductive capacity of top-level predators such as orcas. Chemical contamination of sediments and water has been documented to directly and indirectly result in suppressed reproduction, disruption of homing, higher rates of liver disease, and the feminization of some male fishes.

Oil spills and chronic small-scale oil discharges pose toxicological risks to orcas, birds, and other marine life. Studies have shown that even relatively small oil spills from vessels that are not commercial oil carriers have resulted in tens to hundreds of oiled birds washing ashore, and each spill can kill an estimated hundreds to thousands of birds. While major oil spills are rare events in Puget Sound (and the United States), small spills from vessels that are not commercial oil carriers are likely to continue to be a major threat to seabirds and other marine life.

In addition, litter and detritus can harm Puget Sound species. Derelict fishing gear can trap, wound, or kill marine species and degrade marine ecosystems and sensitive habitats, among other adverse effects. The Northwest Straits Marine Conservation Initiative estimates that there are approximately 4,000 derelict fishing nets in Puget Sound. A recent study shows that at an average rate of entanglement, each net could entangle 92 invertebrates, 13 fish and 7 seabirds each month. Other types of debris, such as small pieces of plastic or cigarette filters, can kill wildlife that eats them. Lead poisoning from consuming lead shot and fishing weights is a leading cause of death for wild trumpeter and tundra swans in Whatcom County.

**Harvest**

Over harvest of rockfish and Pacific hake has been identified as a risk factor to those populations. Overharvest is an identified threat to ESA-listed populations of Chinook salmon in Puget Sound. In the mid-1980s, the median exploitation rate of Puget Sound Chinook stocks was 85 percent; in the mid-1990s the median exploitation rate dropped to 45 percent. The decline of pinto abalone populations has also been attributed to overharvest. Harvest may have cross-trophic impacts, as predators experience declines in important prey. Harvest also may indirectly impact non-target species such as other fishes, birds, and porpoises which are unintentionally captured (by-catch). The impacts of harvest on non-target species, such as scoters and harlequin ducks, are uncertain. Most fishing methods and gear inadvertently impact species or species forms (e.g., hatchery or wild forms) that were not intended to be handled or harvested because the methods are not completely selective for the targeted species.

**Cultured Species**

The culture of salmon in hatcheries is a recognized risk to threatened salmon in Puget Sound, and a potential threat to depressed rockfish populations as a result of increased predation. Hatchery fish, by interbreeding with wild fish, may lower the fitness of those populations to survive and reproduce successfully in the wild. Salmon may escape from private hatcheries (i.e., netpens in saltwater) and compete with native species. Hatchery fish may heighten risks such as disease (including viral hemorrhagic septicemia) and overharvest, and contribute higher concentrations of PCBs up the food chain than do wild fish. Sea lice, a potentially lethal parasite, were nearly nine times more abundant on wild juvenile pink and chum salmon near salmon farms holding adult salmon than in areas distant from salmon farms in British Columbia. The National Marine Fisheries Service identified three issues associated with net pens as posing high risk to Puget Sound: the impact of fish feces and uneaten feed on the environment beneath net pens, the impact on benthic communities of accumulated heavy metals in sediments below net pens, and the impact of pharmaceuticals and pesticides on non-target organisms. However, these risks vary depending on site conditions – such as the level of flushing at the site – and government regulation for the use of specific therapeutic compounds.
Shellfish aquaculture methods, pervasive in some areas of Puget Sound, modify beaches and the lower intertidal zone, but impacts on populations or the ecosystem have not been well studied. A recent review of the ecosystem-level effects of shellfish aquaculture determined that while more study is needed, the available literature indicates that intensive shellfish aquaculture may divert materials to benthic food webs, alter coastal nutrient dynamics, and have cascading effects on estuarine and coastal food webs. In particular, the effects of geoduck aquaculture on the benthic environment and fauna, the food webs, water quality, and aesthetics are a current concern but very few studies have been conducted to examine them.

Species culture, from agricultural forestry to aquaculture, may contribute pollutants to the environment (e.g., herbicides and antibiotics) and facilitate introduction of invasive species (e.g., the invasive dwarf eelgrass, Zostera japonica, was shipped along with Japanese oysters for cultivation). In addition, many species grown for aquaculture in Puget Sound are invasive species, such as Manila clams, Mediterranean mussels, Pacific oysters, and Atlantic salmon.

Invasive Species
In the U.S., invasive species are the second most common threat to imperiled and federally listed species, following habitat degradation and loss. Invasive, non-native species can have a wide variety of adverse effects on native species and habitats, including competing with or feeding on native species, reducing the resilience of ecosystems, changing local habitats, affecting flood patterns, and introducing diseases. Invasive species enter the Puget Sound basin through a number of pathways: importation of seeds, plants, fruits, and vegetables; in ballast water discharges from ships; in soil brought in with nursery stock; on commercial and recreational boat hulls; on travelers' clothes and shoes, cars, and airplanes; in solid waste and soil dumped as fill in wetlands; and from people who release exotic pets and plants “into the wild.”

In the Puget Sound basin, purple loosestrife, Spartina spp., Sargassum muticum, knotweed, Scotch broom, and other invasive species threaten native ecosystems and species. Spartina, a non-native perennial grass, has been shown to be transforming estuarine intertidal habitats. Studies demonstrate a link between domestic animals (including feral cats and rodents), freshwater runoff, and transmission of the potentially fatal disease Toxoplasma gondii to river otters in the San Juan Islands and southern sea otters in California. Invasive species are a threat to more than a quarter of the plant species in Washington that are of conservation concern.

Human Disturbance
Many species, such as orcas and birds, suffer from human disturbance and noise both below and above water, often resulting from people who wish to enjoy observing wildlife. Vessel effects, including those of whale-watching boats, were listed as one of the primary threats in the listing of Southern Resident killer whales. Intertidal invertebrate communities can suffer from the effects of clam harvesting and trampling. Nesting waterbirds are particularly sensitive to disturbance from wildlife-watching humans, and often abandon their nests either temporarily or permanently, endangering the survival of their young.

Natural Forces/Variability
Species and biodiversity are also susceptible to natural forces, including hazards such as earthquakes, tsunamis, storms, floods, and wildfires; natural hypoxia, algal blooms, or forest succession; natural variations in rainfall, ocean currents and temperatures, snowmelt, air temperature, and climate; and disease. Anthropogenic threats may accelerate, amplify, or act synergistically with natural forces, reducing organisms’ resiliency to natural threats. For example, anthropogenic factors and climate change influence disease risk in terrestrial and marine ecosystems. Although they have not been well studied in the marine biota of Puget Sound, diseases do exist that have the ability to affect multiple taxa including ecosystem engineers such as Zostera marina, Pacific herring, and social species such as killer whales.
B. Main gaps in our understanding of threats

There is much we do not know about the forces that threaten species survival, or about how the interactions between natural and anthropogenic stressors affect populations and alter food webs and biodiversity. We do not understand the cumulative effects of stressors and major drivers, the magnitude of impacts from individual stressors, or the relative importance of threats. For example, we do not comprehensively understand the magnitude of threats from individual invasive species, or the distribution of invasive species infestations.

Perhaps the largest gap is in our understanding of the impacts of climate change on biodiversity and species. Current predictions incorporate our best estimates of future changes in the Northwest weather regime, based on global-scale models, combined with our understanding of the impacts of these changes on species and ecosystems. While new empirical data on climate change impacts continue to inform these projections, uncertainties in the data and model assumptions make it difficult to forecast effects precisely. However, scientists project that these effects are likely to be significant and wide-ranging.

Current Status of Puget Sound Biological Life Compared to ‘Healthy’ Condition

A. What is the definition of healthy condition?

In its 2006 report, the precursor to the current Puget Sound Partnership described a healthy Puget Sound: “Puget Sound forever will be a thriving natural system, with clean marine and freshwaters, healthy and abundant native species, natural shorelines and places for public enjoyment, and a vibrant economy that prospers in productive harmony with a healthy Sound.” In terms of species, biodiversity, and the food webs, a healthy Puget Sound will have “healthy and sustaining populations of native species in Puget Sound, including a robust food web,” with the following related outcomes:

1. Terrestrial, aquatic, and marine species exist at viable levels into the future and biodiversity of the overall ecosystem is naturally maintained.
2. Invasive species do not significantly reduce the viability of native species and the functioning of the food web.
3. The harvest of fish, wildlife, shellfish, and plant species is balanced, viable, and ecosystem-based.

A healthy Puget Sound is dynamic and resilient. Conditions may naturally change over time through random events or large-scale catastrophic or climatic events, from tsunamis to multi-decadal climate oscillations, but a healthy Puget Sound will be resilient enough to respond to these changes.

More scientific work is required to analyze the question of “how much is enough” for the majority of species in the Puget Sound basin. Defining thresholds for abundance, productivity, spatial structure, and diversity for key species will enrich the definition of a healthy Puget Sound, and enable the Partnership to measure the health of species, biodiversity, and the native food webs.

B. Where does the current condition meet, exceed, or not meet these reference conditions?

The current condition varies by species, and in many cases is not known. For example:

- Many Puget Sound species are meeting or exceeding reference conditions. Most groundfish and Pacific herring stocks are in good condition, as are intertidal invertebrates. (However, several important Pacific herring and groundfish populations have undergone substantial declines.) Many managed species are providing productive and rewarding harvest opportunities including intertidal clams, geoducks, Dungeness crabs, sea urchins, and sea cucumbers. Harbor seals have been steadily increasing in population since the early 1970s, and their population size is very close to its upper limit within the carrying capacity of Puget Sound. Species that respond well to disturbance, such as the western scrub jay and the American robin, have increased in numbers in recent years.
And, in a positive sign of the success of conservation efforts, the bald eagle was recently removed from the federal list of threatened species, and the brown pelican has been proposed for delisting.82

- The status of many of the thousands of plant and animal species in the Puget Sound region is not known.
- Twenty-one species are listed as threatened or endangered by the state and federal governments, and the state government lists 157 species of concern.
- Cultural icons such as orcas are in serious decline. As of October 2007, there were 87 documented Southern Resident orca individuals, compared to historical estimates of 140 to 200 individuals.26
- Many other formerly abundant species are declining, such as the pinto (northern) abalone, sea ducks, grebes and loons, rockfish, Pacific cod, Pacific whiting (hake),83 and Lake Sammamish kokanee.19
- Given the declines in many species, it is likely that the native food webs of Puget Sound are significantly altered from their historical condition.

References
32 Washington Department of Natural Resources, undated. Summary of Key Findings – ShoreZone Inventory.


82 Federal Register: February 20, 2008, Proposed Rule. 73(34):9408-9433

Science Question 2 (S2): Management Approaches Addressing Species, Biodiversity, and the Food Web

What we know, from a scientific standpoint, about the effectiveness and certainty of management approaches aimed at addressing threats to key species, biodiversity, and the food web

This section of the discussion paper provides an overview of the scientific literature describing the effectiveness of management approaches used in the Puget Sound basin and elsewhere to reduce threats to species, biodiversity, and the food webs.

A. What are the main scientific findings relating to management approaches and their documented effectiveness?

Management approaches designed to address key threats to species, biodiversity, and the food webs have been in place for decades. Despite the monitoring, land use, harvest-management, and other approaches tried over the years, species – and thus the food webs and biodiversity – continue to decline in Puget Sound. Currently, Washington State agencies list 157 species in the Puget Trough Ecoregion¹ as species of concern.¹

The Land Use and Habitat, Water Quality, and Water Quantity Topic Forums are addressing the effectiveness of management approaches aimed at reducing threats such as habitat alteration, pollution, and surface and groundwater diversion. This memorandum focuses on approaches designed to address the decline of specific species, and to manage harvest, invasive species, and cultured species. It also examines management approaches more broadly, and highlights those management approaches that are thought to be most effective. For the purposes of this paper, a management action is considered "effective" if it accomplishes its goal, whether that goal is to protect a species, its prey, biodiversity, or the food webs.²

Species Plans

Species conservation and recovery plans are prepared for species listed as threatened or endangered under the federal Endangered Species Act (ESA) and/or by the Washington Department of Fish and Wildlife (WDFW).² These recovery plans have had some successes at bringing back individual species, such as the delisting of the bald eagle in 2007,³ or the proposed delisting of the brown pelican in 2008.⁴ A study by the Center for Biological Diversity shows that listed species with recovery plans in place for two or more years were significantly more likely to be improving and less likely to be declining than species without such plans in place. Furthermore, species with critical habitat designated for two or more years were more than twice as likely to be improving, and less than half as likely to be declining, as species without critical habitat designations.⁵ The authors identified critical habitat designations as part of these plans as a key factor for recovery success, and noted that implementation of the plan (as measured by expenditures) appeared to be positively correlated with species recovery.

Management plans have also been developed for other Puget Sound species which are not listed as threatened or endangered. For example, the harvest of geoduck is managed under the Commercial Geoduck Fishery Management Plan, as well as on a local basis through cooperative agreements with relevant Tribes.⁶ Groundfish

¹ Please note that the Puget Trough Ecoregion extends north into British Columbia and south into Oregon, and therefore may contain species of concern that do not occur in Puget Sound.

² State law (WAC 232-12-297) requires conservation of listed species through preparation of recovery or management plans, which direct WDFW to address the threats to listed species. The Fish and Wildlife Commission has the authority to classify wildlife as endangered or protected under RCW 77.12.020. Species classified as endangered are listed under WAC 232-12-014, as amended. Species classified as protected are listed under WAC 232-12-011, as amended.
and forage fishes are managed under the Puget Sound Groundfish Management Plan and the Forage Fish Management Plan, respectively.\textsuperscript{7} An analysis of recovery plans suggests that such multi-species plans are less effective at ensuring species recovery than individual-species recovery plans,\textsuperscript{5} and the Groundfish Management Plan has had mixed results. Trends in species status information suggest some successes, such as the slight improvements in the number of groundfish and forage fish stocks in good condition during recent years.\textsuperscript{8} However, a recent review of the Groundfish Management Plan identified gaps in the plan that may be hindering conservation efforts,\textsuperscript{9} and as the result of a petition NMFS is currently reviewing the status of Puget Sound rockfish in consideration of an ESA listing.

Large-scale Habitat Conservation Plans (HCPs) developed recently by state agencies are landscape-based and include provisions for multiple species.\textsuperscript{10} However, the intent of HCPs is to protect sensitive species and their habitat while allowing certain activities to continue,\textsuperscript{11} rather than to serve as a comprehensive plan for recovery.

There are many other management plans for harvested species and some wildlife species, but the majority of Puget Sound species are not managed under plans, and our understanding of the status and trends of those species is limited.\textsuperscript{8}

**Harvest Management**

Many species in the Puget Sound basin are subject to harvest for commercial, recreational, scientific or cultural purposes. Further detail on regulations governing these activities can be found in Response to Question P1. WDFW and the Washington State Department of Natural Resources (WDNR) regulate harvest of non-fish marine species, in some cases in partnership with treaty Tribes. Timber harvest is guided by the 1994 Northwest Forest Plan, the Washington Forests and Fish Law, and several Habitat Conservation Plans. Harvest of some non-timber forest products is regulated by the WDNR.

Many Puget Sound Indian Tribes have reserved rights to harvest a variety of species, including fish and shellfish. As established through treaties and case law, Tribes and Washington State share authority and responsibility for managing fish and shellfish harvests. Federal and Washington State agencies, Tribes, and citizen groups have developed fish management plans and recovery plans which address harvest, hatchery, and habitat impacts on species such as the Puget Sound Chinook and the Hood Canal summer-run chum.\textsuperscript{12}

Harvest management has resulted in a decrease in the overall harvest mortality of wild Chinook salmon in Puget Sound,\textsuperscript{13} and can prevent overharvest of many species, such as halibut, salmon, geoduck, sea urchins, sea cucumbers, and other invertebrates.\textsuperscript{14,15} Management of some species according to the precautionary principle (see “Other Management Approaches” below) has been implemented, but not evaluated for effectiveness. For example, groundfish harvest for live fish markets has been prohibited, as has the commercial harvest of seaweed and any fishing for six-gill sharks.\textsuperscript{16,17} An additional benefit of harvest management is that required catch and population abundance data can be useful species-status information for purposes other than harvest management.

Many harvest quotas do not consider the other ecosystem services that species provide.\textsuperscript{18} For example, salmon harvest quotas are based upon spawning escapement goals, forecasted run sizes, and exploitation rates. While these quotas consider survival and recovery of salmon, they do not consider the number of salmon necessary to feed Southern Resident killer whales, bald eagles, California sea lions, and other predators. The Puget Sound Salmon Recovery Plan recommends more concerted efforts to integrate harvest, hatchery, and habitat management.\textsuperscript{19}

In other cases, harvest quotas are set too high or not set at all. Studies have identified harvest as a risk factor for rockfish, Pacific hake, and pinto abalone populations in Puget Sound.\textsuperscript{20,21,22} Harvest of birds, non-timber forest products, such as maple for guitars, salal or moss for floral arrangements, and bark for medicines, is not always subject to regulation and, if regulated, is often inadequately and inconsistently enforced.\textsuperscript{23} The ecological impacts of this minimally-managed harvest are not well assessed, but some of the harvest species are slow-growing (e.g., moss) and others are essential for forest nutrient cycling (e.g., mushrooms).\textsuperscript{24}
Marine Protected Areas (MPAs), including marine reserves, are increasingly proposed as an enforceable fishery management tool.\textsuperscript{25,26} Research on the effectiveness of MPAs for economically valuable, mid-trophic level species suggests that bigger reserves, and reserves that account for species’ dispersal ranges, are better at protecting species.\textsuperscript{25} Apostolaki et al. modeled the effects of marine reserves on spawning stock biomass and short- and long-term yields, and found that reserves could benefit overexploited stocks of low-mobility species, as well as, to a lesser extent, underexploited stocks and high-mobility species. They found greatly increased resilience to overfishing within reserves.\textsuperscript{26} Marine reserves established in Puget Sound by WDFW appear to have some benefit to rockfish and lingcod; however benefits to species outside the reserve have not been demonstrated.\textsuperscript{27} MPAs have had mixed effectiveness for marine mammals and marine predators.\textsuperscript{25}

**Cultured Species**

The Washington State Department of Agriculture is responsible for managing aquaculture as well as agriculture, while the U.S. Fish and Wildlife Service, Puget Sound Indian Tribes and Nations, and the Washington State Department of Fish and Wildlife operate fish hatcheries.\textsuperscript{28} The WDNR and the Forest Practices Board manage forest culture operations.

The effectiveness of these management efforts varies between culture practices and impacted species. For example, captive breeding of members of threatened or endangered populations can prevent extinctions and help with reintroductions.\textsuperscript{29} Cultured salmon benefit human well-being by maintaining tribal culture and providing commercial and recreational benefits.\textsuperscript{29,30,31} On the other hand, salmon hatcheries appear to limit the genetic diversity and alter the life histories of wild salmon,\textsuperscript{13} and have been identified as a potential threat to depressed rockfish populations.\textsuperscript{22} New species such as lingcod or geoduck are being cultured or considered for culture without extensive research into potential impacts, while cultured species continue to be a vehicle for introducing invasive species.\textsuperscript{32}

**Invasive Species**

Invasive non-native species are among the top threats to imperiled species nationally.\textsuperscript{1} In Puget Sound, purple loosestrife, *Spartina* spp., *Sargassum muticum*, knotweed, Scotch broom, and other invasive species threaten native ecosystems and species.\textsuperscript{33} Taking early measures to avoid invasive non-native species appears to be significantly more effective than post-invasion eradication, as once established, some invasive species are virtually impossible to completely eradicate. Early action to remove species while infestations are small is more effective (and less costly) than removing them after they have infested large areas.\textsuperscript{34}

**Derelict Gear Removal**

The Northwest Straits Initiative removes derelict fishing gear, including both nets and pots or traps, from Puget Sound. A recent cost-benefit analysis of the program demonstrated that removing this gear is cost-effective even when considering only the directly measurable monetized benefits of derelict gear removal – the commercial vessel value of species saved from mortality over a one-year period. Indirect benefits, such as improved human safety, habitat restoration, removal of barriers to navigation and reduced pollution, were not considered.\textsuperscript{35} A recent study shows that at an average rate of entanglement, each of the estimated 4,000 nets in Puget Sound could entangle 92 invertebrates, 13 fish and 7 seabirds each month.\textsuperscript{36}

**Ecosystem-Based Management**

Despite the effectiveness of many of the approaches described above, such as single-species recovery plans, the Puget Sound ecosystem has continued to decline. One indicator of this decline is that government agencies in the Georgia Basin-Puget Sound ecosystem continue to add to their lists of species of concern: Between 2002 and 2004, 14 species were added to these lists. The total number of species on the combined lists – 63 – is indicative of ecosystem decline.\textsuperscript{37}
To arrest this decline, many scientists suggest focusing on ecosystem-based management, which accounts for the linkages between species and addresses system-wide factors of decline. Ecosystem-based management represents a shift away from single-species or single-issue management toward a focus on these linkages. The U.S. Ocean Policy Commission and the Pew Ocean Commission both called for a shift to ecosystem-based management, and NOAA is following their lead by conducting an Integrated Ecosystem Assessment (IEA) of Puget Sound, with plans for a future U.S. West Coast IEA. The IEA will provide a formal synthesis and quantitative analysis of information about how relevant natural and socio economic factors relate to ecosystem-management goals. This synthesis will provide the scientific underpinnings for an ecosystem-based management approach for the Puget Sound basin.

A recent paper describes the principles that ecosystem-based management approaches for the ocean generally include:

1. Define the spatial boundaries of the marine ecosystem to be managed.
2. Develop a clear statement of the objectives of ecosystem-based management.
3. Include humans in characterizations of marine ecosystem attributes and indicators of their response to change.
4. Use a variety of strategies to hedge against uncertainty in the ecosystem response to ecosystem-based management approaches. These strategies can include regulations, incentives, rewards, marine reserves, and others.
5. Use spatial organizing frameworks such as zoning for coordinating multiple management sectors and approaches.
6. Link the governance structure with the scale of the ecosystem elements to be managed under an ecosystem-based management approach.

Ecosystem management is designed to protect ecosystem structure, functioning, and key processes, formed on concepts such as:

- Changes in the abundance of any species can have unintended consequences in the ecosystem. For example, increased abundance of pinnipeds such as harbor seals and California sea lions in Puget Sound (due to their protection under the Marine Mammal Protection Act) has negatively affected populations of Pacific herring and may be inhibiting recovery of several fish species, including Pacific hake, walleye pollock, and Pacific cod. Similarly, the return of the bald eagle may be responsible for the unusually high mortality of common murre nestlings at Tatoosh Island.
- Dramatic variability is to be expected, thus a long-term focus is necessary. The abundances of species are inherently difficult to predict, especially over longer time periods, in part because they may change abruptly and with little warning. For example, decadal-scale changes such as the North Atlantic Oscillation or the Pacific Decadal Oscillation can abruptly and unexpectedly alter ecosystem dynamics and species abundances.
- Ecosystems are not infinitely resilient.
- Ecosystem services are nearly always undervalued.

Although many scientists call for a shift to ecosystem-based management and some management agencies have adopted it in principle, ecosystem-based management has been implemented only rarely. Little is known about its effectiveness in action.

Management on the ecosystem scale is expected to be most effective if it is undertaken through coordinated action across agencies with a clear plan. The U.S. Government Accountability Office (GAO) reviewed the Chesapeake Bay Program, and found that the program lacks a comprehensive, coordinated implementation strategy, and that some of
the partners’ efforts or plans are inconsistent with each other or perceived as unachievable by program partners. The GAO questioned the program’s ability to effectively coordinate restoration efforts and manage its resources.42

Washington has found successes in locally-based, multi-stakeholder management processes. For example, Marine Resource Councils appear to effectively raise awareness of and mobilize local support for conservation and increase voluntary compliance with conservation goals.43

**Other Management Approaches**

Two approaches to managing the uncertainty associated with species, biodiversity, and the food webs that are championed by many in the conservation community are the precautionary principle44 and adaptive management.45

**The precautionary principle** encourages policies that protect human health and the environment in the face of uncertainty.46 It is based on taking precautionary measures on activities that raise threats to human health or the environment, even if all the cause and effect relationships have not been fully established scientifically.47,48 Kriebel et al. (2001) describe the precautionary principle to have four central components: “taking preventative action in the face of uncertainty; shifting the burden of proof to the proponents of an activity; exploring a wide range of alternative to possibly harmful actions and increasing public participation in decision making.”46 The State of California has adopted the precautionary approach as a starting point for addressing 19 fish species.49

**Adaptive management**, designed to deal with uncertainty, is considered by some as a method to implement the precautionary principle.50 Adaptive management occurs through an iterative process in which management approaches are developed and applied, their impacts are monitored and assessed, and management approaches are modified based on findings. In practice, it may take many years for adaptive management of a given ecosystem to accurately measure and document the effectiveness of management techniques. While adaptive management is widely supported in concept, in practice it is often less effective than expected, due in many cases to the complexity of the human institutions and ecosystems being managed.45

The National Research Council has identified a continuum of management actions: protection, restoration, enhancement and rehabilitation. Mitigation, particularly compensatory mitigation, can adopt any of these approaches to minimize or eliminate a net impact. Protection is identified as the most effective management approach. Restoration is most effective when pursued with the goal of recovering natural ecosystem processes that maintain and reestablish natural biodiversity and complex ecosystems, but it requires integrated, coordinated efforts to address all ecosystem components at an appropriate scale. Mitigation, the least effective approach because it seldom involves true restoration and often attempts highly-uncertain ecosystem creation, can alleviate some detrimental effects of ecosystem loss but rarely achieves full restoration.51

**B. How is the effectiveness of management techniques measured and documented?**

While a number of agencies and groups monitor species’ abundance or health in the Puget Sound ecosystem, little of this monitoring is done with the goal of informing modifications in management approaches.52

For example, the Puget Sound Assessment and Monitoring Program (PSAMP) has been monitoring key indicators of water and sediment quality, nearshore habitat, shellfish beds, and the health of fish, seabirds, and marine mammals for almost 20 years. While PSAMP has provided a wealth of information on species health, abundance, diversity, and distribution, these data are not well-linked to management objectives or specific strategies.53

The Washington Department of Fish and Wildlife monitors a network of 18 marine reserves in Puget Sound for research purposes. Scuba divers estimate fish densities, measure individual fish, and identify and quantify lingcod nesting activity.8 While these data do have relevance for the impacts of harvest on species, benefits for species or overall population management outside the reserves have not been demonstrated.
Washington’s Forum on Monitoring has begun implementing a statistically-designed multi-agency evaluation of the effectiveness of watershed recovery efforts for salmon through a program of intensively monitored watersheds. Baseline data were collected in 2004-2005; other results have not yet been published.

One very important step in evaluating the effectiveness of management techniques is clearly articulating goals and choosing indicators. For example, the GAO review of the Chesapeake Bay Program found that the program’s monitoring efforts were weakly tied to assessments of progress toward identified goals. Identified goals may not necessarily benefit the ecosystem as a whole; as discussed above, the effectiveness of harvest and/or hatchery management is usually discussed in the context of the managed species, but management impacts on other species in the ecosystem are usually not addressed.

C. From a scientific standpoint, which approaches have been documented to have the most effective results relative to abundance, productivity, spatial distribution, and diversity?

Management approaches that appear to more effectively protect and promote species, biodiversity, and food webs include aggressively preventing species invasion, taking an ecosystem approach to management, and prohibiting or limiting harvest in set-aside areas.

- Taking early measures to avoid problematic invasive non-native species appears to be significantly more effective than post-invasion eradication in promoting species abundance, productivity, spatial distribution, and diversity.
- Harvest management can effectively maintain or enhance the status of the target species. Revised harvest quotas that reflect the needs of other species in the ecosystem are expected to have more widespread benefits.
- If implemented, single-species recovery approaches, such as those under the ESA, can effectively restore the target species. In addition, the in-depth focus on ailing species can uncover hidden problems, such as the effects of DDT on eggshells. However, single-species recovery plans do not account for effects on other species, or on the ecosystem as a whole.
- Derelict gear removal has been shown to be cost-effective in Puget Sound.
- Comprehensive management approaches addressing ecosystem and harvest needs are more certain to benefit the ecosystem than current single-species harvest management approaches.
- There is strong scientific consensus that ecosystem-based management will more effectively ensure healthy, intact, and resilient ecosystems with diverse and abundant species.

While these management approaches have been shown to be effective, we do not have a sense of the relative magnitude of the threats they address.

References

Policy Question 1 (P1): Policy Approaches to Address Species, Biodiversity, and the Food Web in Puget Sound

This section of the discussion paper describes the regulatory, voluntary, educational, and other approaches that a wide variety of organizations are undertaking to protect and restore species, biodiversity, and the food webs in the Puget Sound basin.

A. Threats being addressed by existing regulations or management programs

Puget Sound’s growing human population poses multiple threats to marine, estuarine, and upland ecosystems. Habitat alteration, climate change, impacts to surface and groundwater quantity, pollution, harvest, cultured species, and invasive species will continue to put marine, estuarine, freshwater, and upland ecosystems and species at risk.1,2

Agencies and organizations use many policy approaches to manage or reduce threats in Puget Sound, including incentives, education, voluntary stewardship, regulations, plans, and programs. The Partnership recently requested these organizations to submit summaries of their Puget Sound-related activities; the inventory of these activities demonstrates the great breadth of programs and numbers of people working on the behalf of Puget Sound species, biodiversity, and the food webs. A non-exhaustive sampling of these is provided below, organized by threat.

In addition, it is important to note that many agencies and multi-stakeholder groups have created management plans to address single species, multiple species, or even all of Washington's biodiversity. These plans typically contain provisions to address multiple threats. Examples of these plans and programs include the Washington Biodiversity Conservation Strategy, the Washington Invasive Species Council 2008 Strategic Plan, the Puget Sound Salmon Recovery Plan, the Pacific Region Seabird Conservation Plan, the Northwest Forest Plan, the Pacific Salmon Treaty, state and federal species recovery programs, and the Washington Department of Fish and Wildlife's (WDFW) Comprehensive Wildlife Conservation Strategy and Priority Habitats and Species Program. Regulations that address multiple threats to species, biodiversity, and the food webs include (but aren't limited to) the Growth Management Act, the Coastal Zone Management Act, the Forest and Fish Act, and the Clean Water Act.

Habitat Alteration

- **The federal** Endangered Species Act (ESA) focuses on protecting and recovering species and the ecosystems that support them. Under ESA, species may be listed as threatened or endangered and can be afforded legal protections. The ESA provides the legal foundation for the development of recovery plans for listed species. It allows incidental take of listed species. Federal agencies are required to consult with the U.S. Fish and Wildlife Service and the National Marine Fisheries Services about their activities. Non-federal entities can develop voluntary Habitat Conservation Plans (HCPs) before taking actions on their land that may incidentally harm (“take”) a threatened or endangered species. The ESA also requires the federal government to identify and designate critical habitat for any listed species.3 The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental effects of their proposed actions, and reasonable alternatives to those actions, as part of their decision-making processes.4

- **Tribes** around Puget Sound work to restore and enhance habitat in their treaty areas to reverse the decline of species and other natural resources.5,6

- Several **Washington State** agencies are completing ecosystem-based, multi-species HCPs under the Endangered Species Act. The WDNR is developing an HCP for aquatic lands7 and WDFW is developing multi-species HCPs for wildlife management areas and for Hydraulic Project Approvals.8 (Please see the Land Use/Habitat Protection and Restoration Topic Forum discussion Paper for more information about the HPA program.) Since 1997, WDNR has managed its timber lands under an HCP.9 While HCPs primarily focus on actions that may “take” threatened or endangered species, they can allow for some flexibility in management.
Like its federal counterpart, the Washington State Environmental Policy Act (SEPA) requires state and local agencies to include the environmental consequences of an action in their decision-making process.10

- **Cities and counties** implement Comprehensive Plans, Shoreline Master Programs, Critical Areas Ordinances, zoning laws, and other regulations that have provisions to protect species habitat from development and disturbance. For example, Whatcom County and Bainbridge Island include provisions for forage fish spawning in their Critical Areas Ordinances.11 Cities and counties must also comply with SEPA. Eleven Puget Sound-basin local governments have adopted transfer of development rights programs to protect open space and guide development.12 The City of Seattle also has an HCP for the Cedar River Watershed, designed to protect both the City's water supply and habitats for 83 species of fish and wildlife in the watershed.13

- **Citizens and non-profit organizations** monitor birds, fish, beaches, and streams in an effort to inform scientists and managers about ecosystem conditions and potential threats to these resources. Examples are numerous but include Washington State University Extension's Beach Watcher program, the Salmon Watchers program, and many others.

Please see the Land Use and Habitat Topic Forum Discussion Paper for more information about how habitat alteration is being addressed in Puget Sound and the effectiveness of these approaches.

**Surface / Groundwater Impacts**

- **The Washington Department of Ecology** (Ecology) has established or is working to establish instream flow rules in all 12 Puget Sound watersheds except San Juan (WRIA 2) and Island (WRIA 6), to protect and preserve instream resources and values such as fish, wildlife, and recreation.14 Ecology also is charged with implementing the Water Resources Act of 1971.15

- **Citizens, local governments, state agencies, and Tribes** are working together in several Water Resource Inventory Areas across Puget Sound to develop watershed management plans that address surface and groundwater quantity.

- **Local governments and water purveyors** develop water system plans detailing future water supply and conservation measures.

Please see the Water Quantity Topic Forum Discussion Paper for more information about how surface and groundwater impacts are being addressed in Puget Sound and the effectiveness of these approaches.

**Pollution**

- **Tribes** monitor water quality across Puget Sound.16

- **The federal** Clean Water Act regulates point sources of water pollution such as factories and wastewater treatment plants, and provides for management of non-point sources such as agricultural runoff.

- **The Washington Department of Ecology** implements the Clean Water Act, including the state's program under the umbrella National Pollutant Discharge Elimination System (NPDES) and is responsible for monitoring and regulating water quality state-wide.

- **Many counties and cities** in Puget Sound, especially those planning under Phases 1 and 2 of the NPDES, have adopted Ecology's 2001/2005 Stormwater Management Manual for Western Washington or its equivalent.17

Please see the Water Quality Topic Forum Discussion Paper for more information about how pollution is being addressed in Puget Sound and the effectiveness of these approaches.
Harvest

- **Treaty Tribes and state agencies share responsibility for managing fish and shellfish harvests.** The federal government, Washington State agencies, Tribes, and citizen groups have developed fish management plans and recovery plans which address harvest, hatchery, and habitat impacts on species such as the Puget Sound Chinkook, bull trout, Hood Canal summer-run chum, and many food fish.

- **State government agencies** also regulate harvest of non-fish species. Commercial harvest of kelp and seaweed from aquatic lands is prohibited with specific exemptions, while recreational harvest is permitted by WDFW and WDNR. Recreational and commercial harvest of shellfish is permitted by WDFW. WDNR manages geoducks in partnership with WDFW and treaty Tribes.

- **Federal, state, tribal, and county** governments in Washington collaborated with those in Oregon and California to develop the 1994 Northwest Forest Plan, with the goal of producing timber while protecting and managing related species. Similarly, the federal, state, tribal, and county governments and private forest landowners worked together to create the Washington Forests & Fish Law and its HCP to allow timber harvest while still protecting streams and salmon. Federal, state, and private forest landowners have worked together to create three major HCPs on private timber lands.

- **The WDNR** issues permits for harvest of specialized non-timber forest products including Christmas trees, native ornamental trees, evergreen foliage, cedar products and salvage, mushrooms, and cascarbark.

- **The Washington Department of Fish and Wildlife** has established a series of marine reserves to protect iconic or reference habitats and species. WDNR has established Aquatic Reserves to protect habitats.

Invasive Species

- **Washington State and federal agencies are working with their counterparts in Oregon, California, Alaska, and British Columbia** to address invasive species across political boundaries. WDFW manages aquatic nuisance species, focusing on non-native invasive mussels. All state and federal land-management agencies are actively involved in removing invasive species from their lands.

- A number of **Tribes** in the Puget Sound basin are actively involved in addressing non-native invasive species, including *Spartina* spp. and knotweed.

- **The Washington Invasive Species Council** provides policy level direction, planning, and coordination for combating invasive species and preventing introductions. The Council’s strategic plan, released in June 2008, identifies 22 immediate and long-term recommendations with specific action items, including an effort to determine the invasive species pathways that lack defenses and address those gaps. The plan also shows the diversity of groups working on controlling invasive species, including the Washington Noxious Weed Control Board, the Washington Aquatic Nuisance Species Committee, the Washington Biodiversity Council, and the Washington Tunicate Response Advisory Committee, among many others.

- **The Washington State** Ballast Water Management Act of 2000 (as amended) requires vessels to manage ballast water in ways to reduce the introduction of invasive species to receiving waters. The Washington Ballast Water Workgroup is working with industry representatives to meet requirements in that Act.

- **Citizens** monitor for invasive species such as tunicates and European green crab.

Human Disturbance

- **The federal Marine Mammal Protection Act** prohibits disturbing or harassing marine mammals. Similarly, the ESA prohibits harassing, harming, pursuing, collecting, or capturing listed species.

- **The Washington State Legislature approved and Governor Gregoire** recently signed a bill requiring all vessels to stay at least 300 feet away from orcas.

- **WDFW** publishes management recommendations for priority species that include provisions to reduce human disturbance. For example, the recommendations for great blue herons include buffers from all human activity of at least 820 feet between February 15 and July 31.
• **Local programs** such as the Seattle Aquarium’s Beach Naturalist program train volunteers to teach beachgoers how to view and appreciate intertidal life without harming it.32

**B. Threats not being addressed, and why**

Despite many good efforts, including but not limited to those described above, all of the stressors outlined above continue to threaten species, the food webs, and biodiversity. As the human population of Puget Sound grows by a projected 1.5 million over the next 20 years, it is likely that threats such as pollution, reductions in water quantity, disease, and habitat loss and degradation will intensify.

The Land Use/Habitat, Water Quantity, and Water Quality Topic Forums are addressing habitat loss, water quantity, and water quality threats. This section discusses limitations to how threats posed by harvest management, cultured species, invasive species, and climate change are being addressed:

• Threats to biodiversity and the food webs posed by the culture of species are not comprehensively addressed. Culture sites such as forests or net pens can fragment habitat, the addition of cultured species into Puget Sound can adversely affect the food webs,33 and disease risk in hatcheries is elevated.34

• Harvest management rarely considers the impacts of harvest on species linked in the food webs and on the ecosystem as a whole.

• The responsibility for management of many species rests with WDFW and the Tribes, while those species use public and private lands and waters managed by others. There is no framework to make cohesive ecosystem-based management evaluations or decisions across these authorities. This increases the potential for habitat fragmentation or management plans working at cross purposes. For example, WDFW has 18 marine protected areas but WDNR manages the aquatic lands underneath them and could lease the sites for other purposes. Conversely, WDNR has several large Aquatic Reserves, yet WDFW allows many types of harvest within those reserves.

• Harvest of non-timber forest products, such as salal, mushrooms, and cascara bark, is difficult to manage, and illegal harvest is a growing problem.35

• While programs to control noxious weeds have been in place in Washington for decades, the infrastructure to manage invasive animals, as well as funds to eradicate or control invasive species, are lacking. More dedicated management of invasive species in marine and estuarine environments has been identified as a pressing need.36

• Human disturbance, such as trampling along shorelines associated with recreational activities, can have significant effects on species.37 While many parks and management agencies have issued guidelines designed to minimize these impacts, regulations and public education could more effectively protect refuges, hauled-out marine mammals, seabird colonies, rafting seabirds, shellfish, and others.

• The state and many local governments and citizens are beginning to take action on reducing greenhouse gas emissions, but climate change is expected to continue to impact species and biodiversity in coming decades.

There are many institutional challenges and barriers to addressing threats to species, biodiversity, and the food webs. For example, authority to manage invasive species is fragmented, such that agencies frequently work in isolation to evaluate risks, develop prevention strategies, and control the threat of an invasive species. Even when regulatory authority is clear, agencies may lack flexible funding with which to tackle the problem.29 In many cases, lack of resources or political will weakens management efforts and enforcement of existing laws, while in others our incomplete understanding of the problem precludes implementation of a truly effective management approach.2 Management of these threats is also complicated by overarching drivers that are particularly difficult to address; e.g., climate, ocean conditions, the global economy, scarcity of and competition for natural resources, human population growth, and individual and collective lifestyle preferences.30
The institutional framework for managing marine ecosystems is complicated by issues of scale. While most biological management efforts occur at the state and federal level, many of the decisions that affect Puget Sound biota are made by local governments and individual residents and visitors. Ownership across nearshore and upland systems is fragmented, and protection of aquatic environments is weakly correlated with ownership because of the fluid nature of the ecosystem and the mobility of many of the component species. In addition, habitat loss and pollution outside of Puget Sound can affect migratory species that reside part-time in Puget Sound.

Local governments are often constrained in enforcing laws protecting nearshore ecosystems, due to lack of resources and fears of legal challenges and political opposition. Conflicting mandates complicate management at the state level: For example, the WDFW is funded in part by its management of resource harvest, yet it is simultaneously charged with species conservation.

C. Species plans to address population, abundance, distribution and/or diversity

Currently, Puget Sound species which have been listed as threatened or endangered by the state and/ or federal government include:

- Puget Sound Chinook Salmon
- Pacific Fisher
- Hood Canal/E. Strait of Juan de Fuca Chum Salmon
- Northern Spotted Owl
- Bull Trout
- Western Pond Turtle
- Northern Pacific Humpback Whale
- Mardon Skipper
- Puget Sound Steelhead
- Taylor's Checkerspot
- Steller Sea Lion
- Golden Paintbrush
- Southern Resident Orca
- Water Howellia
- Northern Sea Otter
- Grizzly Bear
- Marbled Murrelet
- Mazama Pocket Gopher
- Western Grey Squirrel
- Streaked Horned Lark
- Gray Wolf

Recovery or conservation plans have been developed, or are being developed, for most of these threatened or endangered species.

Other Puget Sound species that are not listed as threatened or endangered are managed under state plans. WDFW manages at least 80 species of groundfish and at least 8 species of forage fishes under the Puget Sound Groundfish Management Plan and the Forage Fish Management Plan. The WDNR manages geoduck harvests under the Commercial Geoduck Fishery Management Plan, and co-manages geoduck and intertidal shellfish harvests on a regional basis with specific Tribes.

D. Species without plans or programs either in place or planned

There are thousands of marine, estuarine, freshwater, and upland species that are not managed through recovery plans, such as unclassified marine invertebrates and fishes. An estimated 157 species in the Puget Trough Ecoregion have been listed as species of concern by Washington State; the status of many others is unknown.

E. Plans or programs in place to address food web status and biodiversity in the Puget Sound region

There is no institutional structure for managing biodiversity or food webs. The 2007 Washington Biodiversity Conservation Strategy contains a number of recommendations that, if implemented, should help to address biodiversity in Puget Sound. These include:

- Using the Ecoregional Assessment tool to guide prioritization of habitat conservation;
• Using incentive programs and technical assistance to support conservation among private landowners;
• Supporting local governments in managing growth and development, as well as existing laws, plans, and regulations;
• Improving mitigation programs;
• Conducting public outreach; and
• Establishing a Biodiversity Science Panel and a Biodiversity Data Partnership, as well as a Biodiversity Inventory to document all species in the state, and a Biodiversity Monitoring Plan to track the status of those species.

These recommendations were developed based on input and results from groups working to conserve biodiversity in Washington and beyond. For example, The Nature Conservancy has found that Ecoregional Assessments provide a common information base, identify additional data needs, and help to build partnerships essential to conservation. Conservation incentive programs have proved to be a successful non-regulatory method to help private landowners steward their land. A pilot citizen biodiversity stewardship project in Pierce County underscored the importance of local government support for biodiversity conservation.

Additional work informing management at an ecosystem scale includes the Ecoregional Assessments conducted by The Nature Conservancy, the WDFW Wildlife Conservation Strategy, and an effort to improve ecosystem-based management through an Integrated Ecosystem Assessment of Puget Sound. There is also significant research underway on better understanding of Puget Sound food webs, but there are no existing management approaches directed toward food web goals.

F. Other types of plans or programs used in other locations to address species and biodiversity

A range of plans and programs are being used in marine, estuarine, freshwater, and upland ecosystems across the world to address species and biodiversity. For example:

• Many U.S. states adjoining marine waters or the Great Lakes have strategies for biodiversity conservation, including Oregon, California, Hawaii, Wisconsin, Maine, Delaware, Massachusetts, New Jersey, and Florida.
• California’s Marine Life Management and Protection Act directed the state to design and manage a network of marine protected areas in order to, among other things, protect marine life and habitats, ecosystems, and natural heritage, as well as improve recreational, educational and study opportunities.
• Under the Georgia Basin Action Plan, Environment Canada, the British Columbia Ministry of Environment, and others conduct monitoring and biological stream assessments in four Georgia Basin watersheds, with the intent of providing needed information to sustain healthy aquatic environments in the Basin.
• Ireland’s National Biodiversity Plan calls for practices to conserve biodiversity such as the preparation of a National Integrated Coastal Zone Management Strategy, the development of a National Marine Biodiversity Resources Database, and enhanced surveys and research on marine biodiversity.
• The National Strategy for the Conservation of Australia’s Biological Diversity aims to protect biological diversity and maintain ecological processes and systems. Australia also has created a set of national objectives and targets for biodiversity conservation to augment the National Strategy, and set targets for 10 priority outcomes.
• In 2008, New Zealand released a final policy and implementation plan to protect its marine biodiversity by establishing a comprehensive and representative network of Marine Protected Areas. The country also has a comprehensive, nationwide Biodiversity Strategy.
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16 E.g., see Clallam County OSS Management Plan.
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Policy Question 2 (P2): Needs Assessment and Actions: What Are the Gaps?

This section of the discussion paper summarizes the management approaches that seem to be effective at protecting or restoring species, biodiversity, and the food webs in the Puget Sound basin. It also identifies programs that will need to be changed, and new programs that need to begin, to improve the health of the biota in the basin. Lastly, it suggests criteria to use to select among actions, and discusses the need for monitoring.

Addressing the Threats to Species and Biodiversity in Puget Sound

A. Plans and programs that are on track to address identified threats, and why

Currently, the Puget Sound basin lacks a comprehensive approach to managing threats to species, biodiversity, and the food webs. However, a number of individual plans and programs appear to be on track to address identified threats. These include the following:

- **Management plans** focused on individual species or groups of species can be effective at addressing multiple threats to those species. Perhaps the most famous example in Puget Sound is the delisting of the bald eagle, but other species’ populations have improved under focused management.1,2 Species recovery plans such as the Puget Sound Chinook Recovery Plan and multi-species and broader management plans such as the Washington Biodiversity Conservation Strategy identify many ways to address identified threats. The completion of these plans is a first step toward conservation outcomes; their implementation is critical to achieving tangible benefits. To date, implementation of these plans is lagging due to insufficient funding. The detailed recommendations for protection and restoration projects, improvements in management approaches, and targeted scientific inquiries contained in these plans will be a critical component of restoring the health of species, the food webs and biodiversity in Puget Sound.

- **Improved harvest management techniques** have benefited their target species. For example, better harvest management has led to a decrease in the overall harvest mortality of wild Chinook salmon,3 and could be used to prevent overharvest of many species, such as halibut, salmon, geoduck, sea urchins, sea cucumbers, and other invertebrates.4,5 Use of the precautionary principle to eliminate commercial harvest pressure on seaweed and sharks and other fishes has reduced pressure on and slightly improved the health of groundfish stocks.6 Implementation of the recommendations from such efforts as the Puget Sound and Coastal Washington Hatchery Reform Project7 should also improve hatchery practices so that they contribute to recovery of species in Puget Sound.

- **An increased focus on human disturbance effects** will also help address the threat that human disturbance poses to a variety of species. A new state law that requires vessels to stay 300 feet away from orcas is a step in the right direction. Local programs such as the Seattle Aquarium’s Beach Naturalist program train volunteers to teach beach-goers how to view and appreciate intertidal life without harming it.8

- **Swift action to avoid the introduction of non-native species** is more effective than trying to eradicate established invasive species.9

- **Multi-stakeholder groups** have been shown to be effective at mobilizing local support for conservation and increasing voluntary compliance with conservation goals.10 They also provide forums for collaboration between and among stakeholders and resource managers.

- **Collaborative science programs** such as the Hood Canal Dissolved Oxygen Program partner scientists and managers in strategic studies and recommending actions.

- **Prevention efforts** have proven successful. For example, oil-spill prevention efforts, such as the deployment of a tug in Neah Bay and increases in vessel inspections, have markedly decreased the number and volume of oil spills in Puget Sound since 1986.11 The Marine Mammal Protection Act prohibits
harassing or killing marine mammals. Since its passage, some populations of marine mammals have increased in Puget Sound. Populations of bald eagles and peregrine falcons rebounded after DDT was banned.

B. Gaps between existing programs or plans and identified needs (what is missing from what we do now?)

Although many programs and management efforts are making progress toward their goals, Puget Sound lacks an ecosystem-based management framework to protect and restore marine, estuarine, freshwater, and terrestrial species, biodiversity, and the food webs. As preliminary recommendations for the working group to consider, this ecosystem-based management approach should include the following:

- An institutional framework that includes all levels of government, Tribes, scientists, and a wide variety of stakeholders. Successful implementation of an ecosystem-based management approach will depend upon all agencies and entities adopting the same form of ecosystem management. Strong leadership will be necessary to knit all the agencies and entities together into a cohesive planning and implementing body. This framework must develop a way to overcome the gaps between institutions – such as the fact that WDNR manages the lands under WDFW’s groundfish reserves, or that Ecology manages water rights but local governments manage growth – as well as modifying the mandates of institutions as necessary. For example, WDFW is charged with recovering priority species but is partly funded by hunting and fishing licenses; WDNR manages aquatic and forest lands but must use them to generate funding. The framework should also include a focus on strengthening trans-boundary collaboration with Canada.
- A comprehensive approach to identifying and managing drivers of ecosystem change as well as threats to species, biodiversity, and the food webs. Because there currently is no system for managing the food webs, this approach would fill a major gap. This approach must also prioritize among actions to protect and restore species, biodiversity, and the food webs, and hold entities accountable for implementation.
- A comprehensive science program to coordinate research and monitoring efforts. These efforts must include status and trends, cause and effect, validation, and effectiveness monitoring. The ecosystem-based approach should establish goals, outcomes, and indicators, and ensure that monitoring efforts “roll up” through an accurate model to create a picture of ecosystem health. Because ecosystem models are still in development, qualitative outcomes should be evaluated with respect to the principles of adaptive management and the precautionary principle. This monitoring program should maintain a balance between a focus on chosen indicators and research on aspects of the ecosystem that are not indicators.
- A dedicated, sustainable funding source for management efforts, the science program, and maintenance of the institutional framework.

Creating this ecosystem-based approach will require ingenuity and creativity to develop new tools and modify existing ones. It will require strong leadership and willingness to take risks.

What areas or issues need the greatest attention or action and why?

Creation of the ecosystem-based approach should begin immediately to organize and coordinate the myriad of actions necessary to recover species, biodiversity and the food webs in the Puget Sound basin.

C. Actions which may need to be changed (programs or mandates that conflict, are not focused on key problems, overlap, or have some other inefficiency)

The ecosystem-based approach should serve as an umbrella under which many successful programs continue to promote species, communities, and biodiversity. Some may need to be changed somewhat to fit within the ecosystem perspective. For example:
• Species recovery planning efforts should continue and be nested within this approach. Restoring individual species within the food webs requires the dedication and detailed investigation that species-recovery efforts generate. An ecosystem-based approach could suggest ways to broaden these efforts to consider the ecosystem services these species provide.

• Species-management efforts also should continue but be integrated across agencies and levels of government. The Partnership should create a suite of recovery and/or management plans for both listed and unlisted species that focuses on managing species for recovery and sustainability.

• Harvest management efforts also should continue. Nesting them within the ecosystem-based management approach will require evaluating harvest quotas and management practices to ensure that they help achieve ecosystem and food web goals in addition to economic, cultural, and recreational goals.

• Similarly, culture-management efforts should continue but expand to consider the effects of culture on other species, biodiversity, habitat, and the food webs.

• Efforts to manage specific threats, such as human disturbance or invasive species, should continue. Nesting them within this approach will require an examination of how they meet ecosystem goals.

• Scientific programs such as the Puget Sound Assessment and Monitoring Program should continue but be adjusted as necessary to ensure they inform management decisions supporting the ecosystem-based goals and objectives, and support tracking indicators of progress toward goals and objectives.

Shifting to an ecosystem-based management approach would tie all of these efforts together and unite them in making progress toward a single set of goals. It would also drive us beyond our current focus on species toward a more comprehensive understanding of species interactions, the food webs and biodiversity in the Puget Sound basin, from the marine waters to alpine regions.

Which actions need the greatest attention?
All of these actions require attention, but the ecosystem-based framework must be created first. However, it is important to note that many actions can and should continue while the ecosystem-based framework is being created.

Which criteria should be considered for prioritizing actions to address species, biodiversity, and the food web?

Developing an ecosystem-based approach to recovering Puget Sound’s food webs and biodiversity will require agreeing upon a set of goals and outcomes for the ecosystem, as well as indicators for tracking progress toward those goals. That effort likely will also generate a set of criteria for prioritizing actions to achieve the outcomes and goals.

In the meantime, some criteria to consider include the following:

• **Urgency:**
  o Is it urgent? Does it effectively address endangered or declining species?
  o Does it keep common species common or protect functioning ecosystems or habitats?

• **Effectiveness:**
  o Does it affect multiple species, biodiversity or the food webs?
  o Does it address the cause of the problem, rather than a symptom? Does it address multiple threats or limiting factors?
  o Can the effects of the action be discriminated from natural variability in the system?
  o Do we have a good sense that it’s going to work, based on the science?
  o Can we evaluate this action so that it leads to adaptive management?
Does it lead to human behavior change that will improve ecosystem conditions?

Is it cost-effective?

- **Steps toward ecosystem-based management:**
  - Does the action improve coordination between and integration of managers, implementers, and scientists?
  - Does it amplify and/or integrate the scope(s) of existing efforts so that they contribute to ecosystem goals?
  - Does the action build our understanding of the ecosystem and/or limiting factors?
  - Does it consider sustainable species needs as well as human well-being?
  - Does it consider the precautionary principle, if its effects on the ecosystem are unknown?
  - Does the action inform citizens, scientists, and/or managers about species trends and corresponding appropriate actions?

**A. Where should we start? Why?**

Citizens, non-profit agencies, tribal and government entities, and multi-stakeholder groups have already poured tremendous effort into recovering species (and by extension, the native food webs and biodiversity) in Puget Sound. We should build on that good work.

That good work includes hundreds of suggested actions to address dozens of species. Rather than attempting to select among them, we suggest five areas in which to focus efforts initially:

1. Begin developing an ecosystem-based management approach to, and institutional framework for, recovering Puget Sound.
2. **Take action where we know there is urgency:** restore declining species and keep common species common. Implement existing species-recovery and multi-species plans, and plans to protect biodiversity and prevent non-native species invasions. Create plans for other imperiled species and communities, with the goal of creating a suite of recovery and/or management plans that focuses on managing species for recovery and sustainability.
3. Protect or conserve habitats or areas with high biodiversity and high potential value to the food webs.
4. Continue to build our understanding of the food webs, threats to the food webs and biodiversity, and the effectiveness of management actions so that we can manage adaptively. In particular, conduct research to build our understanding of trends, patterns, and mechanisms of change in species, biodiversity, and the food webs.
5. Undertake a critical assessment of harvest and culture practices to see where they could be improved, particularly regarding maintaining harvested species' roles in the ecosystem and ensuring that culture practices protect the ecosystem.

**B. What immediate or short-term actions (next biennium) are needed? What is the rationale?**

In the short-term, we need to create the ecosystem-based framework and take action where we know there is urgency. Although there will always be some uncertainty associated with our actions, we still must act where we are reasonably certain the actions will have benefits to the Puget Sound ecosystem.
Begin to design an ecosystem-based management approach:

1. Assemble partners for the ecosystem-based management approach, and begin work on identifying goals, outcomes, and indicators. NOAA’s Integrated Ecosystem Assessment project should form the basis of this work. Find ways to incorporate existing efforts, such as the Washington Biodiversity Council’s work to create a new institutional framework and embed the Biodiversity Conservation Strategy as an organizing principle for natural resource agencies. Ensure that terrestrial and freshwater systems are well represented in this approach. Pursue the goal of creating a suite of recovery and/or management plans that focuses on managing species for recovery and sustainability.

2. Develop and implement a funding strategy designed to create a stable, dedicated, long-term funding source for ecosystem-based management.

Rationale: An ecosystem-based approach is more likely to recover the Puget Sound ecosystem than a piecemeal approach. Stable funding is necessary to ensure success.

Take action where we know there is urgency:

- Implement the most urgent actions in existing plans, such as those for single species, multiple species, biodiversity, and invasive species. Emphasize actions that we know are effective or that can further our knowledge of effectiveness of management actions. For example, complete the development of and implement the regional and watershed adaptive management programs for the Puget Sound Salmon Recovery Plan.
- Create and implement plans for imperiled species and communities.
- Prioritize and enforce existing regulations and start reviewing their effectiveness.
- Fix existing regulations that have known problems.
- Assess marine, estuarine, freshwater, and terrestrial areas to find the representative and high-quality areas.
- Protect known high-quality and representative areas using a variety of tools and incentives.
- Assess whether current protected areas (terrestrial and aquatic) are adequately protected to ensure the sustainability of imperiled and common native species. Fill gaps where they are found.
- Take steps to prevent introduction of invasive species, and to remove them where already established and harming the ecosystem.
- Continue and expand efforts to minimize human disturbance effects on species and communities where they have been shown to be detrimental.
- Continue and strengthen efforts to remove pollutants (including debris and derelict gear) from water and sediments, and thus from the food webs.
- Create and implement community-based social marketing programs to encourage behavior changes to protect biodiversity and the food webs.
- Link the conceptual models developed for different parts of the Puget Sound basin into a network to identify the most relevant ecosystem indicators and guide overall ecosystem monitoring, and to link drivers and pressures to changes in species or food web status.
- Select indicators and develop an understanding of species, biodiversity, and the food webs as a baseline against which to monitor progress and manage adaptively. Monitor these indicators and publish trend information about them on a regular basis, potentially as a scorecard.
- Implement short- and long-term status and trends, effectiveness, validation, and other types of monitoring.
- Ensure that monitoring measures both natural variability and the effects of management actions.

Rationale: These actions should help prevent extinction, recover declining species, and protect biodiversity and the food webs.
C. What long-term actions are needed? What is the rationale?

Take action where we know there is urgency:

1. Continue to implement actions listed above.
2. If new species are listed, develop and implement recovery plans for them within the ecosystem context. Continue to pursue the goal of creating a suite of recovery and/or management plans that focuses on managing species for recovery and sustainability.

Rationale: These actions should help prevent extinction and recover declining species.

Begin to design an ecosystem-based management approach:

Continue to implement – and adjust as necessary – the ecosystem-based approach.

Rationale: An ecosystem-based approach is more likely to recover the Puget Sound ecosystem than a piecemeal approach. Stable funding is necessary to ensure success.

Protect important habitats:

Develop and implement methods to protect the marine areas of Puget Sound that support high levels of biodiversity (measured as species richness or productivity) or support rare species. Partner with the Washington Biodiversity Council and Washington Invasive Species Council to implement the Washington Biodiversity Conservation Strategy and the Washington Invasive Species Council’s strategic plan. Identify and protect habitats critical to the survival of declining species and to keeping common species common.

Rationale: Once we know which areas of Puget Sound are important for protecting biodiversity, we should protect them.

Build understanding of species, biodiversity, the food webs, and the effectiveness of management actions:

1. Design a comprehensive research program to inform the ecosystem-based management approach. Draw upon the recommendations of many existing plans and studies to create this program. Include the monitoring programs mentioned in the previous section. To maximize effectiveness, existing monitoring programs will need to be integrated, and gaps between them identified and filled.

2. Conduct research to constrain and define the problem: What are the Puget Sound native food webs? This research should be designed to provide information about trends, patterns, and mechanisms of change in the native food webs, so that we can discriminate between natural and human-caused changes.

3. Develop and implement a rigorous monitoring program to evaluate the effectiveness of management actions that discriminates between natural variability and the effects of management actions.

4. Create and disseminate a Species, Biodiversity, and Food Webs scorecard that publicizes the results of the monitoring programs and illustrates the health of species, the food webs, and biodiversity in the Puget Sound basin. Partner with the Washington Biodiversity Council, which is working on such a scorecard.

Rationale: There are very large gaps in our knowledge, particularly of the native food webs in Puget Sound. A comprehensive, coordinated research program should help fill those gaps and help us understand what change is natural and what change is human-caused – and therefore where we should focus our management actions. Understanding which management actions really work is a key part of adaptive management.

Undertake a critical assessment of harvest and culture practices:

1. Design and conduct an assessment of harvest and culture practices focused on the effects of current practices on the ecosystem, particularly on the food webs and its supporting habitats. Keep abreast of
ongoing research activities into the effects of harvest and culture, such as the current focus on geoduck aquaculture.

2. Adjust harvest and culture practices as necessary to protect and restore the ecosystem.

Rationale: Current harvest practices protect their target species, but don’t consider the links between those species and other species in the food webs. Similarly, culture practices ensure the propagation of target species but don’t consider their effects on the food webs. This assessment will help align these practices with ecosystem goals.

How will we know we are making progress on species, biodiversity and the food web?

To know whether we are making progress, we must first understand where we are now. Our knowledge of species, biodiversity, and the food webs varies dramatically depending on the species and the ecosystem, as described below. The paragraphs below describe the essential information needed to establish baselines against which to measure our progress.

Species: We know a great deal about some species, particularly those that are culturally or economically important, or that are listed under the Endangered Species Act. However, we know very little about thousands of other species, including primary producers such as phytoplankton. We will need to conduct research about these species to develop a baseline before we can know whether we are making progress. Initial research should focus on key or indicator species that will help advance our knowledge of the health of the ecosystem. Lastly, we need to answer the question “how much is enough” for the abundance, productivity, spatial structure, and diversity of key species so that we can measure progress toward viable species populations.

Biodiversity: Our understanding of terrestrial biodiversity is fairly good at some trophic levels, and our understanding of freshwater aquatic biodiversity is less so. We know even less about marine biodiversity and the areas that are important to protect. We will need to develop a map of marine habitats and the biodiversity they support before we can measure improvements.

Food Webs: We know relatively little about Puget Sound’s native food webs. Information about predator-prey interactions, the structure of the food web, phytoplankton and zooplankton, spatial and temporal variations, and how plant and animal communities work together in the terrestrial, freshwater, estuarine, and marine environments is lacking. Before we can evaluate progress on increasing the resiliency of the food webs, we need to understand what changes in the food webs are natural and which are human-caused.

A. What objectives should we consider to monitor progress?

Some objectives to consider include:

- No more species merit listing, and common native species stay common.
- Populations of currently listed species are increasing or recovered.
- Ecosystems are representative of the natural state and variability of Puget Sound, and are sustainable as such. We should avoid management that seeks to isolate and “fix” naturally dynamic ecosystems in one “target” state.
- The food webs contain robust, redundant nodes (such as important primary consumers) and pathways that maintain the ecosystem’s resilience to natural and human-caused disturbances.
- We protect productive habitats as well as species-rich ones.
- We develop an independent, self-sustaining source of funding to support management and scientific programs.
B. What actions and outcomes would be important to monitor in evaluating progress on this topic?

**Status and trend of ecosystem conditions**
Monitoring should include:

- Trends in and status of species’ abundance, productivity, spatial structure, and diversity
- Trends in and status of the food webs
- Trends in and status of biodiversity (see scorecard recommendation above and in the Washington Biodiversity Strategy)

**Status and trend of threats**
Monitoring should include:

- Indicators of climate change, harvest and culture practices, and human disturbance
- Trends in and status of invasions of non-native species, and their effects on native species’ abundance, productivity, spatial structure, and diversity (see Invasive Species Council Strategic Plan)

**Implementation of programs**
Monitoring should include:

- Progress toward adjusting harvest management and culture practices to account for ecosystem services
- Progress toward developing an ecosystem-based management approach
- Progress toward implementing actions

**Implementers’ compliance with program requirements**
Monitoring should include:

- Effectiveness of efforts to improve the institutional framework for ecosystem-based management

**Project, program, and/or strategy effectiveness (in achieving direct outcomes)**
Monitoring should include:

- Effectiveness of management efforts, such as changes in harvest-management practices
- Effectiveness of enforcement, protection, and restoration actions

**Research and other studies of the underlying assumptions about strategies and programs**
As discussed above, a comprehensive research program is necessary to create a framework for understanding the food webs, biodiversity, communities, and many species in Puget Sound. This program must include validation monitoring and a gap analysis, and quantify and evaluate threats and limiting factors. Since some species migrate beyond the borders of the Puget Sound basin, it will be necessary to coordinate efforts with other states and countries such as Canada.

Any monitoring program should be aligned well with the goals of ecosystem-based management, and its results should be summarized regularly in a scorecard useful for communicating outcomes or progress to the public and elected officials. In addition, the monitoring program should include tracking of some ecosystem characteristics that aren’t selected as indicators, to ensure that we don’t miss potentially important signals and new threats to the
ecosystem. The monitoring program should evolve over time to reflect new findings – and new questions. There is much monitoring work that can begin now, before the comprehensive program is complete.

Finally, the data produced via this monitoring program must be easily accessible and coordinated.

C. What aspects of progress evaluation are most important to start immediately? Why?

The Puget Sound Partnership has identified outcomes for the ecosystem. A critical first step will be to transform those outcomes into more detailed metrics that can be measured. In addition, developing and implementing a comprehensive research program to deepen our understanding of Puget Sound's native food webs and biological communities is an important action to begin immediately. Lastly, we can begin to evaluate the effectiveness of existing management actions now to better inform our choices in the future, monitor implementation actions, and begin the development of an adaptive management plan.

References

Appendix 1: Definitions

Biodiversity
Biodiversity is the full range of life in all its forms. This includes the ecosystems in which life occurs, the way that species and their habitats interact with each other, and the physical environment and the processes necessary for those interactions.

This definition includes all species found within the Sound, from tiny phytoplankton to towering Douglas firs. The definition also includes the interactions that sustain each species, such as predator-prey relationships, and the physical processes on which life depends, including chemical and nutrient cycling, water filtration, and climate regulation.¹

Biological diversity can be considered at five principal levels or scales:

- **Genetic diversity** within and between species – that is, the unique genetic composition of individual members within a population or variety and the pattern of differences among populations or varieties.
- **Demographic diversity** is represented by a natural frequency of young, middle and older ages and small to large sizes, as well as life history stages.
- **Species diversity** or an index of community diversity that accounts for both species richness and the relative abundance of species. Species richness is simply the number of species present in a community, but relative abundance measures the evenness of species numbers within a community.²
- **Ecosystem structure**, or the composition and organization of plant, animal and microorganism communities that interact with their environment as an ecological unit.
- **Landscape structure**, or the spatial arrangement or patterns of clusters of interacting ecosystems that is repeated in similar associations of topography, vegetation cover, land use and cultural settlement.³

Three commonly accepted measures of biodiversity are richness, rarity, and representation.

- **Richness**, or the number of species present in an area, e.g., the Olympic peninsula’s high number of species,¹
- **Rarity** of species, communities, or ecosystems, characterized by population size, geographic range, and habitat specificity, e.g., the marbled murrelet which nests in old growth forests; and
- **Representation**, or the important species and communities that occur in a local area, e.g., the high biomasses of groundfish and forage fish found in deep water basins and water column habitats.

Other habitats and species contribute to biodiversity through their productivity, such as the shallow, sun-filled sand and mudflats that produce high prey levels and nursery habitats for invertebrates and fishes.

**Cultured Species**
Any species raised by humans for human use is considered a “cultured species” in this paper. These include hatchery fish, cultivated shellfish, managed timber, and all agricultural species.

**Diversity**
When referring to particular species, “diversity” is defined as in the NOAA Viable Salmonid Populations document: “...(D)iversity refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life-history traits.”⁴
Food Web
A food web is a complex of interconnected food chains within and among ecosystems, where a food chain is a sequence of organisms on successive trophic levels that transfer energy and minerals from one to another as each provides food for the next (e.g., phytoplankton, zooplankton, larval fish, small fish, big fish, mammals). Primary producers fix organic matter and this energy is transferred to higher trophic levels through primary consumers (grazers) and carnivores. In estuarine ecosystems such as Puget Sound, many food web pathways also cycle through a heterotrophic pathway, where dead organic matter (detritus) is fed upon by primarily microbial decomposers; this energy moves up the food chain/web. Thus, the types and varieties of food chains and webs are as numerous as the species within them and the ecosystems that support them. The food web is analyzed based on knowledge of the food chains that make it up. This can be further complicated because through various life history stages and changes in distribution, any single species may occupy more than one tropic level within a food chain. 4

References

Appendix 2: Map of Priority Conservation Areas

The attached map is from:

Puget Sound Partnership

Introduction to the Topic Forum Discussion Paper

The attached topic forum discussion paper is one of five papers designed to provoke and inspire enduring community conversation and critical thinking about the specific problems facing Puget Sound, and the strategies and actions needed to overcome the threats we face. These papers are being used to help create the 2020 Action Agenda. Background on the topic forum process and how this information is being used can be found on our website at www.psp.wa.gov in the Action Agenda Center.

The papers represent the first effort in our region to comprehensively synthesize and document what we know about the Sound’s problems, solutions that work, our current approach to solving problems, and what approaches we need to continue, add, or change. These papers address broad science and policy questions, providing an overview of each topic that looks at Puget Sound ecosystem from the crest of the Cascades to the Strait of Juan de Fuca, and documenting the basis of our conclusions and recommendations. They are fundamental to establishing strong connections between science and policy as we develop the 2020 Action Agenda.

The Partnership asked small groups of science and policy experts to prepare each of the draft discussion papers as a starting point. The authors were instructed to rely on readily available existing information and provide a high-level overview of the key issues pertaining to each topic. The draft papers were reviewed by a broad audience, and were discussed at individual topic forums held in April and May. More than 500 people attended the topic forums, and dozens more provided comments on line. During the review period, over 1,200 pages of public comment from were received from 229 people or entities. The Partnership, in conjunction with the papers’ authors, reviewed and considered all of the comments as we prepared these revised discussion papers. Summarized comments and responses are included as appendices to the papers. A complete set of comments will also be posted on the Partnership’s webpage.

The discussion papers are intended to be concise and as brief as possible, providing a synthesis of existing readily available information and an initial list of recommendations for moving forward to achieve the Partnership’s six main goals. Work to integrate the products from the respective topic forums within an ecosystem management framework is ongoing, and will be used to support the Action Agenda. In reading the revised discussion papers, several concepts should be considered:

- **The discussion papers provide an overview of the topic**, summarizing and synthesizing existing documentation. These papers are intended to provide a framework for future management strategies, but are not intended to address in detail all available data on the topic.

- **The Partnership will be identifying priority actions that are based on science.** There is currently a wide range of opinion about the Sound’s problems and literally hundreds of ideas for how to solve them. This was evidenced by the broad range of opinions expressed during the topic forum process. Our goal is to find reasonable consensus on the general nature and magnitude of the documented threats to Puget Sound, so that we have a better chance of prioritizing durable and effective solutions.

- **The papers mainly focus on the Sound as a whole.** We know that there are variations in information availability, type and extent of threats, and workable solutions in different parts of our region. The action area profiles that we are also preparing will help highlight local issues.
• The papers are organized to logically step through three initial questions (two are science and one is policy) that build to a rational conclusion (the fourth question) about the strategies and actions that we will need continue, add, or change as a region. The design is intentional so that 1) our policies are based on science and 2) scientists and policy experts talk to one another.

• The discussion papers will be used to develop cross-topic priorities for the Action Agenda. A number of key themes emerged from the topic forum process, which are being used to help define priorities for management strategies.

• The intent of papers is to focus on WHAT the problem is and WHAT solutions are needed, rather than HOW to implement specific solutions. The Partnership will identify “how” with those who have to implement the solutions.

• The recommendations to the Partnership in the papers represent the conclusion of the authors based on their expertise and comments received. The recommendations will be considered by the Partnership, but should not be interpreted as a Partnership endorsement. This is an intentional design of the topic forum process.

• The papers intentionally do not focus on the need for more education/outreach, new funding strategies including creative incentives, and a coordinated monitoring and adaptive management program. The Partnership knows that these three aspects are critical to long-term success and is using other processes to address them. That work is linked to the development of the Action Agenda. By addressing the system-wide needs, we will be able to more effectively focus the education/outreach, funding, and adaptive management and monitoring strategies.

• A Partnership Quality of Life topic paper is being prepared to follow the other five topic forum papers and pull together human well-being information from each.

• The Partnership Science Panel will review the papers with a specific focus on how well the responses to the two science questions capture current understanding of the topic and key areas of uncertainty. This review is intended to help develop a targeted scientific research program.

The Partnership greatly appreciates the level of interest and participation that reviewers have shown by attending topic forums and providing thorough, thoughtful comments. The comments that we received have greatly expanded and deepened the overall level of discussion, and moved our knowledge forward on these topics. We are committed to continuing this level of engagement.
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The Land Use/Habitat Protection and Restoration Topic Forum team members included:

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- Barbara Dykes, Snohomish County Hearing Examiner,
- Julie Hall, Seattle Public Utilities,
- Charlie Howard, Puget Sound Regional Council,
- Millie Judge, Lighthouse Natural Resource Consulting, Inc.,
- Jennifer Knauer, Jones and Jones Architects and Landscape Architects, Inc.,
- Gino Lucchetti, King County Department of Natural Resources and Parks,
- Harry Reinert, King County Department of Development and Environmental Services,
- Stephen Stanley, Department of Ecology, and
- Dr. Ron Thom, Pacific Northwest National Laboratory.
Science Question 1 (S1): What is the current documented knowledge about threats to ecosystem processes and resulting habitat as a result of land use practices in Puget Sound?

“Habitat” is the biological and physical conditions of an area that support a particular species or species assemblage (Ruckelshaus and McClure 2007). Examples of Puget Sound habitats include high-elevation glaciers, alpine meadows, mid-elevation mixed forests of fir, hemlock, alder and maple, river floodplains, freshwater wetlands, riparian forests, estuarine and tidal marshes, mudflats, eelgrass meadows, and sand and gravel beaches (Kruckeberg 1991; Williams et al. 2001; Ruckelshaus and McClure 2007). Habitats occur within ecosystems, or discrete areas of any size that contain interacting biotic and abiotic elements, and which interact with their surrounding areas (Grimm et al. 2000). Ecosystems and habitats are formed and maintained by the interaction of physical, chemical and biological processes (i.e., ecosystem processes) occurring throughout their watersheds (Spence et al. 1996; Dale et al. 2000; NRC 2001; Roni et al. 2002; Stanley 2005; Simenstad et al. 2006). Specific habitats in Puget Sound can be grouped based on the following general ecosystem types: freshwater, estuarine, marine, and terrestrial.

Ecosystem processes deliver, move, and transform water, sediment, nutrients, pathogens, light, and wood and other organic matter. These processes are responsible for creating and maintaining the habitats that we see and for the functions that habitats provide (Figure S1-1; Naiman and Bilby 1998; Hobbie 2000; Benda 2004; Simenstad et al. 2006; King County 2007; see Appendix S1-1 for more information about processes). These processes exist in a dynamic state and constantly respond to controlling factors such as precipitation or to episodic disturbance events like landslides, fires, seismic events, droughts, and flooding (NRC 1996). These processes can operate at different spatial scales (e.g., regional/large-scale, local/landscape-scale, or finite/small-scale) and exert influence at different time intervals (e.g., daily versus once a century or much longer) and at different levels of magnitude (e.g., bankfull river flows versus 100-year storm event). Native plant, wildlife, and fish species are adapted to and ultimately benefit from the frequency and magnitude of disturbances in their habitats (Reice et al. 1990).

Ecosystem processes form the basis for understanding how habitats are formed and maintained, and for examining the influence that people have on ecosystems. This memorandum provides a brief summary of threats and ecosystem conditions in the Puget Sound watershed, based on readily available existing information. The paper focuses on aquatic aspects of the Puget Sound watershed; further analyses will need to expand on the terrestrial components of the ecosystem. Also, habitat and land use are intertwined. It is important to acknowledge that ecosystem processes are also at the basis of water quality, biodiversity, water quantity, and human health/ and well-being conditions. However, this memorandum will primarily focus on land use and habitat conditions.

Major Stressors on Ecosystem Processes and Habitats

Ecosystem function is produced by biophysical drivers, which in turn direct processes and patterns (Figure S1-1, lower half). Human activities also affect ecosystem function, and those activities flow from social and economic drivers (Figure S1-1, top half). Together, the ecological and socioeconomic drivers form the basis of ecosystems and habitats, including those within Puget Sound.
Human activities can also affect ecosystem processes and threaten the integrity of habitat structures and functions. In this paper, alterations or “threats” are human activities that modify ecosystems, either through eliminating or reducing the ability of a process to occur (e.g., by cutting off beach feeding sediment sources), or through direct alteration of habitat (e.g., dredging). Alterations include such activities as shoreline armoring, removing vegetation, constructing roads and buildings, and harvesting timber. Alterations can affect processes at different scales of space and time.

Table S1-1 lists major threats to Puget Sound ecosystem processes for freshwater, estuarine, and marine, and terrestrial environments and resulting impacts on ecosystem processes. Appendix S1-1 provides more detailed information about ecosystem processes.

---

**Figure S1-1: Ecosystems and their habitats** are shaped by both biophysical drivers and socioeconomic drivers. Biophysical drivers direct ecosystem processes and patterns, and in turn affect ecosystem dynamics. Human activities also affect ecosystem dynamics, and vice versa. Understanding both the biophysical and human sides of ecosystem dynamics is needed to recover Puget Sound habitats. Figure from Grimm et al. 2000. Ecosystem processes are responsible for creating and maintaining habitat structures and the resulting functions. Drivers are natural phenomena that disturb ecosystems and drive long-term maintenance of habitat structures and their functions. Threats are human-driven disturbances to ecosystems that have cascading effects. Adapted from King County 2007.

---

1 In this document, “threats” are human activities that disturb ecosystems. It is synonymous with “stressors,” a term that is often used in scientific literature.
Table S1-1: Major threats to habitats in freshwater, estuary, marine, and terrestrial ecosystems and their resulting impacts on ecosystem processes. The impacts to ecosystem processes change ecosystem dynamics and led to changes in primary and benthic production, vegetation communities, food webs, and species compositions in conjunction with habitat fragmentation and loss.

<table>
<thead>
<tr>
<th>Threat</th>
<th>Ecosystems</th>
<th>Process Impact</th>
</tr>
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<tbody>
<tr>
<td>In-water</td>
<td></td>
<td></td>
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</table>
| Overwater structures (docks, piers, buildings, houseboats) | Marine, estuaries, and freshwater (lakes typically) | Light delivery: benthic shading; shading of the sea floor reduces primary productivity  
Hydrology/Wave energy: redirects/deflects wave energy and currents with influence on sediment and sea floor slopes |
| Marinas                                     | Marine, estuaries, and freshwater (lakes typically) | Hydraulics: redirects/deflects wave energy with influence on sediment and sea floor slopes  
Light delivery: shading reduces primary productivity  
Nutrients: adds nutrients and toxics |
| Dredging, channel straightening             | Marine, estuaries, and freshwater (rivers usually) | Sediment dynamics: reduces sediment supply, changes sediment sizes and slope/depth characteristics, reduces river-floodplain dynamics; |
| Jetties, breakwaters, log booms and rafts   | Marine, freshwater (lakes, reservoirs typically) | Hydraulics: redirect and reduce wave energy and current patterns, at river mouths can also affect tidal prisms and flushing characteristics  
Sediment dynamics: alters depth and availability of substrates, obstructs littoral drift and longshore sediment transport with resulting bathymetry and beach formation changes |
| Groins                                      | Marine (usually)    | Sediment dynamics: intercept littoral drift, reduce sediment movement                                                                 |
| Boat wakes and prop wash                    | Marine, estuaries, freshwater (lakes and rivers) | Hydraulics: increases wave energy, focused scouring  
Sediment dynamics: boat wakes can alter shoreline erosion patterns and change beach profiles, prop wash can scour sediments changing substrate sizes and depths |
Table S1-1: Major threats to habitats in freshwater, estuary, marine, and terrestrial ecosystems and their resulting impacts on ecosystem processes. The impacts to ecosystem processes change ecosystem dynamics and led to changes in primary and benthic production, vegetation communities, food webs, and species compositions in conjunction with habitat fragmentation and loss.

<table>
<thead>
<tr>
<th>Threat</th>
<th>Ecosystems</th>
<th>Process Impact</th>
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</thead>
<tbody>
<tr>
<td>Culverts</td>
<td>Estuaries, Freshwater (rivers and streams)</td>
<td>Hydraulics: reduces stream channel widths, focuses stream flow, increases upstream water levels, can scour stream bed downstream. Sediment: can impede sediment transport through trapping sediment upstream. Wood: reduces wood movement, can reduce supply as wood is removed for maintenance. Light delivery: shades stream. Nutrients: reduces upstream movement of marine derived nutrients.</td>
</tr>
<tr>
<td>Dams, locks and other structures that regulate water levels</td>
<td>Freshwater (rivers and streams)</td>
<td>Hydrology: alters timing and magnitude of flows and flooding, creates inundation zone upstream; alters the floodplain and floodplain dynamics. Sediment: traps sediment on upstream side, decreases or eliminates downstream sediment delivery. Wood: decreases or eliminates downstream wood delivery, decreases wood recruitment upstream.</td>
</tr>
<tr>
<td>Aquaculture (e.g., shellfish farming, fish pens, trout ponds)</td>
<td>Marine and estuaries primarily</td>
<td>Depends on type. Impacts can include increased nutrient loading and pollution, changes to physical beach structure, substrate, and food web and species assemblage impacts.</td>
</tr>
<tr>
<td>Dredge disposal</td>
<td>Marine primarily</td>
<td>Sediment: changes benthic substrates and depths.</td>
</tr>
<tr>
<td>Marine hydropower</td>
<td>Marine</td>
<td>Hydraulics: changes in dynamics of currents. Species mortality.</td>
</tr>
<tr>
<td>Wastewater discharges</td>
<td>Marine, estuaries, and freshwater</td>
<td>Hydraulics: Discharges could alter habitat through scour, etc. Toxics: wastewater can contain chemicals that treatment does not remove (e.g., pharmaceuticals).</td>
</tr>
</tbody>
</table>
Table S1-1: Major threats to habitats in freshwater, estuary, marine, and terrestrial ecosystems and their resulting impacts on ecosystem processes. The impacts to ecosystem processes change ecosystem dynamics and led to changes in primary and benthic production, vegetation communities, food webs, and species compositions in conjunction with habitat fragmentation and loss.

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<tr>
<th>Threat</th>
<th>Ecosystems</th>
<th>Process Impact</th>
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</thead>
<tbody>
<tr>
<td>Vessel releases – sewage, garbage, bilge, etc.</td>
<td>Marine, estuaries, and freshwater</td>
<td>Nutrients: adds nutrients and toxics  &lt;br&gt; Toxics: wastewater and garbage can contain untreated chemicals, metals, petroleum products</td>
</tr>
<tr>
<td>Derelict gear (e.g., traps, nets, garbage, boats)</td>
<td>Marine, estuaries, and freshwater</td>
<td>Mortality to species trapped in gear</td>
</tr>
<tr>
<td>At the water's edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armoring (bulkheads, revetments, seawalls)</td>
<td>Marine, estuaries, and freshwater</td>
<td>Hydrology: increases wave energy at shoreline  &lt;br&gt; Sediment dynamics: restricts sediment recruitment, increases beach erosion, increases steepness of beach profile, prevents backshore, larger homogeneous substrate  &lt;br&gt; Wood: reduces delivery/accumulation of wood and detritus  &lt;br&gt; Nutrients: reduces natural nutrient inputs through removal of native riparian and intertidal vegetation  &lt;br&gt; Light delivery: increases light delivery and temperature due to removal of riparian vegetation</td>
</tr>
<tr>
<td>River levees</td>
<td>Rivers</td>
<td>Hydrology: focuses stream flow, increases localized velocities, restricts floodplain access  &lt;br&gt; Sediment dynamics: reduces sediment storage and recruitment, alters substrate sizes  &lt;br&gt; Wood: reduces wood storage and recruitment  &lt;br&gt; Nutrients: reduces natural nutrient inputs through removal of native riparian vegetation  &lt;br&gt; Light delivery: increases light delivery and temperature due to removal of riparian vegetation</td>
</tr>
</tbody>
</table>
Table S1-1: Major threats to habitats in freshwater, estuary, marine, and terrestrial ecosystems and their resulting impacts on ecosystem processes. The impacts to ecosystem processes change ecosystem dynamics and led to changes in primary and benthic production, vegetation communities, food webs, and species compositions in conjunction with habitat fragmentation and loss.

<table>
<thead>
<tr>
<th>Threat</th>
<th>Ecosystems</th>
<th>Process Impact</th>
</tr>
</thead>
</table>
| Fill/dikes                                       | Estuaries primarily, marine, freshwater (including wetlands) | Hydrology: reduces water storage, in estuary and marine areas alters tidal prism and inundation patterns, reduces river-floodplain dynamics  
Sediment dynamics: increases fine sediment delivery downstream  
Nutrients: reduces biofiltration  
Nutrients: reduces natural nutrient inputs through removal of native riparian vegetation  
Light delivery: increases light delivery and temperature due to removal of riparian vegetation |
| Native vegetation removal, ornamental landscaping| Marine, estuaries, freshwater                    | Hydrology: reduces infiltration and evapotranspiration  
Light: reduces shading allowing for increased temperatures of water or sediments  
Sediment dynamics: increased sediment loading if bank become unstable  
Wood: reduces wood recruitment  
Nutrients: reduces biofiltration, allochthonus inputs;  
Toxics: increases toxic loadings and reduces natural nutrient inputs |
| Boat launches and rails                          | Marine, estuaries, lakes, rivers                 | Hydrology: increases wave energy at shoreline  
Sediment dynamics: restricts sediment recruitment and transport traps sediment  
Wood: reduces delivery/accumulation of wood and detritus |
| Mineral and gravel mining                        | Marine, estuaries, freshwater                    | Hydrology: reduced infiltration and water storage from vegetation removal and soil compaction, increased surface runoff and peak flows in streams from impervious areas and constructed drainage systems, dewatering can cause reduced groundwater and summer low flows  
Sediment dynamics: increase in fine sediments from ground-disturbing activities, peak flows promote bank erosion and can promote stream channel incision and disconnection from the floodplain  
Nutrients: uncontrolled stormwater runoff can cause increase in toxic loading of heavy minerals  
Terrestrial species habitat fragmentation and loss |

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Table S1-1: Major threats to habitats in freshwater, estuary, marine, and terrestrial ecosystems and their resulting impacts on ecosystem processes. The impacts to ecosystem processes change ecosystem dynamics and led to changes in primary and benthic production, vegetation communities, food webs, and species compositions in conjunction with habitat fragmentation and loss.

<table>
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<tr>
<th>Threat</th>
<th>Ecosystems</th>
<th>Process Impact</th>
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<tbody>
<tr>
<td>Away from the water</td>
<td></td>
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</tr>
<tr>
<td>Timber harvest (including impacts from logging roads)</td>
<td>Terrestrial</td>
<td>Hydrology: alters timing of snow melt, reduces groundwater recharge, increases surface runoff and stream peak flows, reduces evapotranspiration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light delivery: increases stream temperatures and reduces dissolved oxygen levels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sediment delivery: increase surface erosion/sediment delivery to streams and wetlands, increased mass wasting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wood: reduces wood and woody debris for aquatic areas</td>
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<td></td>
<td></td>
<td>Terrestrial species habitat fragmentation and loss</td>
</tr>
<tr>
<td>Agriculture/Grazing</td>
<td>Terrestrial</td>
<td>Hydrology: reduces infiltration, alters water patterns and timing with ditching and irrigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sediment dynamics: increases surface erosion, livestock can increase sediment loading through stream bank trampling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nutrients: increase in nitrogen loading, often toxics as well, can have downstream effects that reach waters of Puget Sound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Terrestrial species habitat fragmentation and loss</td>
</tr>
<tr>
<td>Filling of depressional wetlands and other areas</td>
<td>Terrestrial</td>
<td>Hydrology: reduced surface storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nutrients: reduced removal of nutrients through denitrification, adsorption and biofiltration, increase in downstream nitrogen delivery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wetland and terrestrial species habitat loss</td>
</tr>
</tbody>
</table>
Table S1-1: Major threats to habitats in freshwater, estuary, marine, and terrestrial ecosystems and their resulting impacts on ecosystem processes. The impacts to ecosystem processes change ecosystem dynamics and led to changes in primary and benthic production, vegetation communities, food webs, and species compositions in conjunction with habitat fragmentation and loss.

<table>
<thead>
<tr>
<th>Threat</th>
<th>Ecosystems</th>
<th>Process Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impervious surfaces, urbanization (roads, parking lots, buildings)</td>
<td>Terrestrial</td>
<td>Hydrology: reduced infiltration and water storage from vegetation removal and soil compaction, increased surface runoff and peak flows in streams from impervious areas and constructed drainage systems, reduced groundwater and summer low flows. Sediment dynamics: increase in fine sediments from ground-disturbing activities, peak flows promote bank erosion and can promote stream channel incision and disconnection from the floodplain. Nutrients: increase from fertilizers and other sources in addition to an increase in toxic loading. Terrestrial species habitat fragmentation and loss.</td>
</tr>
<tr>
<td>Mineral and gravel mining</td>
<td>Terrestrial</td>
<td>Hydrology: reduced infiltration and water storage from vegetation removal and soil compaction, increased surface runoff and peak flows in streams from impervious areas and constructed drainage systems, dewatering can cause reduced groundwater and summer low flows. Sediment dynamics: increase in fine sediments from ground-disturbing activities, peak flows promote bank erosion and can promote stream channel incision and disconnection from the floodplain. Nutrients: uncontrolled stormwater runoff can cause increase in toxic loading of heavy minerals. Terrestrial species habitat fragmentation and loss.</td>
</tr>
<tr>
<td>Invasive species introduction</td>
<td>Terrestrial (but also marine, freshwater)</td>
<td>Species fragmentation and loss due to competition from non-native species.</td>
</tr>
</tbody>
</table>

**In All Areas**

<table>
<thead>
<tr>
<th>Threat</th>
<th>Ecosystems</th>
<th>Process Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasive Species</td>
<td>Marine, estuaries, freshwater and terrestrial</td>
<td>Alters nutrient cycling, food web dynamic, and other ecosystem processes and patterns. See the Species/Biodiversity Discussion Paper for more information.</td>
</tr>
<tr>
<td>Airborne and sprayed release of pollutants and chemicals</td>
<td>Marine, estuaries, freshwater and terrestrial</td>
<td>Toxics: Released chemicals and pollutants eventually end up deposited in aquatic areas, (e.g., mercury) and can cause toxic loading of chemicals and nutrients.</td>
</tr>
</tbody>
</table>

Gaps in our Understanding of Habitat Process-Structure-Function and Land Use Impacts

While there is strong scientific evidence documenting how certain types of alterations or threats may result in specific changes to habitat structure and function, there are gaps in our understanding of how human land use activities can affect ecosystems. Some of the most significant needs for better understanding of habitat threats for Puget Sound's ecosystems are listed below:

- Nearshore ecosystem processes and linkages to watershed and marine systems, as well as the effects and implications of human activities on nearshore ecosystem processes and habitats (see goals 1 and 2 in Gelfenbaum et al. 2006).
- Deep-water habitat processes in Puget Sound and how those may be affected by future development such as further shoreline modifications, wastewater discharge, and tidal energy generation (see Beechie et al. 2007).
- The cumulative effects of multiple stressors on processes, habitat structure (i.e., biodiversity, spatial patterns in species abundances), and function.
- Resulting ecosystem process and habitat impacts from climate-induced changes in sea levels, air and water temperatures, precipitation and surface water movement patterns, Puget Sound circulation and water quality (Mantua et al. 2007). Impact assessment should examine risk to specific habitats by location.
- Effects of changes in environmental flow parameters (i.e., flood flows, pulses, base flows, and low flows) on riverine habitat, riparian functions, fish communities, and salmon populations.

Current Status of Puget Sound Threats and Habitat Structure

Studies and monitoring of Puget Sound have measured certain aspects of habitat structure (e.g., eelgrass meadows), human-induced threats (e.g., impervious surfaces), and ecosystem function (e.g., shorebird colonies). Rarely have ecosystem processes been addressed. Also, information that is Sound-wide tends to be limited in terms of data detail and accuracy, while the type, quality and quantity of localized information often vary widely among Puget Sound jurisdictions (Anchor Environmental 2007).

There are three major studies underway that will be important in improving our picture of the threats and health of Puget Sound habitats:

1. Puget Sound Change Analysis being conducted by the Nearshore Science Team of the Puget Sound Nearshore Partnership (PSNERP). This analysis will look at changes to shoreforms (based on a PSNERP typology), associated wetlands, and human modifications that have occurred between the 1850s-1870s and roughly 2006. The analysis area will cover the Puget Sound marine shoreline and river deltas extending from an average depth of the photic zone offshore up to 200 meters inland, and will include the contributing watershed conditions. The analysis is expected in late 2008.

2. Risk Analysis for the Puget Sound Ecosystem being conducted by NOAA Fisheries. This analysis will estimate the current status of ecosystem components and conduct a vulnerability assessment. This analysis is expected in early 2009.

3. The Puget Sound Future Scenarios project conducted by the University of Washington Urban Ecology Research Lab, in conjunction with PSNP, identified six possible futures for the Puget Sound region in 2050 (UW Urban Ecology Research Lab 2008). Future steps of this project will use the scenarios and modeling to assess nearshore functions and evaluate alternative restoration strategies.
Table S1-2 provides brief condition summaries for some habitat structures and threats at the Puget Sound level, based on available information (e.g., Ruckelshaus and McClure 2007; PSAT 2007a; Table 2). Appendix S1-2 provides increased details about land use, watershed and terrestrial habitats, and marine and estuary habitats based on Action Area workshop notes, WRIA plans, and reports and studies within counties and cities.

This section is not based on exhaustive literature searches or analysis of data. It is imperative that future studies provide a more complete picture of ecosystem processes and habitat structures and functions within Puget Sound, and describe how and where processes and habitats deviate from their natural conditions (i.e., Puget Sound Nearshore Partnership Change Analysis and NOAA Risk Assessment).

**Table S1-2. Status of select habitat structures and threats at the Puget Sound scale.**

<table>
<thead>
<tr>
<th>Habitat Structure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Cover</td>
<td>There were 5.2 million acres of forest cover in Puget Sound in 2001. Between 1991 and 2001, 2.3% of the forest cover was lost. Over the last 50 years, between 66% and 84% of old-growth forest has been lost.</td>
</tr>
<tr>
<td>Eelgrass (Zostera marina)</td>
<td>Puget Sound contained between 20,000 and 50,000 acres of eelgrass during 2005 monitoring. This Sound-wide area estimate is consistent with results from previous years (2000-2004). While overall eelgrass area appears stable, localized declines suggest otherwise.</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Historically freshwater and saltwater marshes dominated portions of Puget Sound, particularly where larger rivers entered the Sound. It is estimated that about 80% of those wetlands have been lost. Scrub-shrub estuarine wetlands and riverine wetlands have declined over 90% from historic conditions, while estuarine emergent marshes have declined by about 67%.</td>
</tr>
</tbody>
</table>

**Threats**

<table>
<thead>
<tr>
<th>Threats</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified Shoreline</td>
<td>Roughly one-third of the Puget Sound shoreline has been modified with armoring and docks. Numbers are not available for miles of diking, levees, and armoring in freshwater.</td>
</tr>
<tr>
<td>Impervious Surfaces</td>
<td>In 2001, impervious surfaces covered 3.3% of the overall watershed, but at elevations less than 1,000 feet, 7.3% of the land was covered. Between 1991 and 2001, impervious surfaces increased by 10.4% (from ~ 3 to 3.3%).</td>
</tr>
</tbody>
</table>

Sources: Collins and Sheikh 2005; Gaeckle et al. 2007; Ruckleshaus and McClure 2007; PSAT 2007a; PSAT 2007b

**How do current conditions compare to a “healthy” Puget Sound?**

The Puget Sound Partnership goal for habitat is: “A healthy Puget Sound where freshwater, estuary, nearshore, marine, and upland habitats are protected, restored, and sustained.” More specific or numeric goals for the amount and type of habitat needed to reach the goal of a healthy Puget Sound are not yet known. Regardless, to protect, restore, and sustain habitats, ecosystem processes that create and maintain habitat structure must be able to operate at the locations, rates and time scales that support their desired functions and values (Beechie and Bolton 1999; Goetz et al. 2004). At this time, however, it is difficult to assess the condition of processes. Some areas of Puget Sound have much greater information that can be used to conduct assessments, while others have very little information. The result is that there is variable and limited understanding of the integrity of various ecosystem processes throughout the Puget Sound watershed.

Assessment of ecosystem process integrity (i.e., unified, unimpaired, sound, resistant and resilient to disturbances) is critical for understanding current conditions and beginning to assess the extent of protection and restoration necessary to maintain a “healthy” Puget Sound. For freshwater areas, catchment-level analyses can be used, such
as those conducted for King County’s Shoreline Master Program update. This analysis uses information, such as precipitation patterns, surficial geology, forest cover, and alterations such as impervious surfaces to estimate the integrity of the processes that affect water, sediment, wood, nutrients, toxics, and pathogens for a given catchment (King County 2007). Other catchment-level analyses have been completed in eastern Jefferson County and Birch Bay (Ecology 2007; Stephen Stanley, Washington Department of Ecology, pers. comm.) Similarly, process modeling at the drift cell scale has been conducted for marine shorelines using information on shore forms, sediment dynamics, and shoreline modifications. Examples include assessments of eastern Jefferson County2 and Bainbridge Island3; and WRIA 94. Such assessments can help to identify the degree and nature of process impairments and the importance of specific areas for protection and restoration of ecosystem processes.

Moving Ahead on Understanding Ecosystem Processes and Habitat Conditions

Increasing our understanding of ecosystem processes as the basis for assessing condition of habitat structure and ecosystem functions for humans and other species is critical to successful protection and restoration of Puget Sound (Goetz et al. 2004; Simenstad et al. 2006; Beechie et al. 2003). Assessment at the scale of the landscape (e.g., a marine drift cell or freshwater catchment) and site (e.g., a discrete habitat unit within a drift cell or catchment) should be conducted to identify process integrity and importance for specific areas, allowing natural resource managers to cater to specific needs in particular areas. Such assessments are an important component of restoration and protection planning, as discussed in the Response to Question S2. To be useful, these assessments need to consider the hierarchical organization of habitat structures and functions and the time and space scales that relate best to patterns of species use. This work should be conducted to provide a landscape level analysis or classification that can be applied across Puget Sound. Ultimately, this information will inform scientists and decision-makers about where and why ecosystem processes remain intact, are at risk, or are presently altered or absent and in need of restoration to meet desired goals.

______________________________


4Anchor Environmental 2006.
References


King County. 2007. King County Shoreline Master Program, Appendix E: Technical Appendix (Shoreline Inventory and Characterization: Methodology and Results). Available at: http://www.metrokc.gov/shorelines/shoreline-master-program-plan.aspx


Science Question 2 (S2): What do we know about the effectiveness and certainty of protection and restoration approaches aimed at addressing threats to habitat?

Human land use activities, such as logging, building roads and homes, and armoring shorelines, impact watershed and coastal ecosystems (NRC 1992; Booth 1991; Richards et al. 1996; Paul and Meyer 2001; Diefenderfer et al. 2007). Historically, many of these activities occurred without adequate measures to protect habitats and the processes that form them, leaving a legacy of alterations and impacts.

Since about the 1970s, federal, state, and local governments have implemented numerous measures designed to protect the environment and to manage and minimize the adverse consequences of growth with varying success (see Response to Question P1). These measures include:

- Protection of lands outright through acquisition and resource-based zoning (e.g., federal, state and local parks, forest resource lands, acquisition or tax incentives and conservation easements for targeted high resource areas).
- Land use, zoning, and environmental regulations (e.g., federal Clean Water Act, state Growth Management Act, local land use codes).
- Stewardship promotion through education and incentive programs (e.g., tax rebates, salmon and beach “watchers”).
- Modified construction and operation techniques (e.g., low impact development, best management practices).
- Projects to restore and improve habitat, and mitigate for its loss (e.g., culvert removal, riparian planting, wetland restoration or creation).

Despite these efforts, a myriad of human uses of the landscape continue to alter and, by many measures, degrade habitat, leaving our ecosystems at increased risk from existing and future development. Of particular note is that many attempts to restore past impacts and mitigate for ongoing impacts have been unsuccessful at fully replacing the affected habitats or functions (NRC 1992; NRC 2001). Nationally, there has been an estimated 80% net loss of wetlands during the time that the Clean Water Act, Section 404 permitting program has been in place to protect wetland functions (NRC 2001). Within Puget Sound, monitoring by the Puget Sound Ambient Monitoring Program indicates that habitats and species using Puget Sound are in decline (PSAMP 2007b). In addition to habitat losses, we remain unsure about the level of effectiveness of our efforts, and about detailed causal relationships for past failures, because monitoring to evaluate the effectiveness of protection and restoration actions has been infrequent and often inadequate for understanding ecosystem responses (Roni et al. 2003; Beschta et al. 1994; Reeves et al. 1991).

This memorandum discusses the effectiveness of our approaches to protect and restore5 habitats and identifies guiding scientific principles for future habitat protection and restoration.

Effectiveness of Efforts to Protect and Restore Habitat

Overall, little is known about the effectiveness of efforts to protect and restore habitat from an ecosystem standpoint. In general, monitoring efforts that assess restoration and mitigation projects have been increasing in recent years, while efforts to understand the ecological results from regulations, education, incentives, and other sorts of programs remain sparse.

5 In restoration science, “restoration” is limited to those areas where the integrity of ecosystem processes can be reinstated. Habitat rehabilitation and substitution are used in instances where processes cannot be fully reinstated. For the purposes of this document, “habitat restoration” will cover all projects intended to improve habitat conditions.
Effectiveness and status and trend monitoring efforts by a number of entities, such as the Washington Salmon Recovery Funding Board, the Pacific Northwest Aquatic Monitoring Partnership, and individual project sponsors, should help to add to our knowledge about what is most and least effective for ecosystems from the standpoint of projects and the cumulative effects of beneficial and damaging activities.

Below is a brief overview of what is known about effectiveness of protection and restoration actions based on a very limited literature review and web search.

**Habitat Protection Efforts**

Habitat protection efforts can occur through acquisition and creation of reserves, regulations, education and incentive programs, and best management practices. There appears to be little, if any, Puget Sound-wide information about the ecosystem benefits resulting from these efforts. The information available mostly focuses on the intended outputs of the activities (e.g., number of people involved in outreach program, where growth occurs), and not the intended ecological outcome of habitat protection.

For example, there is general consensus that the Washington State Growth Management Act (GMA) is slowing sprawl and focusing growth in urban areas. Between 1995 and 2007 the amount of growth occurring within urban areas increased from 78% to 88% within King, Pierce, Snohomish, Clark, Kitsap, and Thurston Counties (CTED 2008). A study conducted within Thurston County showed a decreasing trend in the number of permits issued within protected areas between 1990 and 2006 (Reaugh and Toebee 2007). However, how that focused growth has protected or benefited ecosystems has not been studied.

The effectiveness of regulations like the GMA and associated Critical Areas Ordinances and the Shoreline Management Act (SMA) are likely to differ by jurisdiction since local governments have some flexibility in the regulations they adopt. For example, single-family residences are generally exempt from the requirement to obtain a shoreline substantial development permit under the SMA. Although these residences must still comply with the goals and policies of the SMA, with 30% or more of the shoreline armoring within Puget Sound occurring as a result of single-family residential development, there is a potential for significant, continuing impacts to Puget Sound health. Similarly, regulatory protections (such as the size of riparian buffers) adopted in Critical Areas Ordinances can vary widely, with each local government making an independent assessment of what the best available science says is necessary to protect those areas.

Acquisition may be the most effective means for long-term protection of habitat conditions. However, protected areas can be affected by land management practices, and changes in surrounding lands. Acquired lands can degrade based on changes to the habitat-forming processes that occur outside of the acquired areas (Lucchetti et al 2005). The value of the area also depends on the types of plants and animals that are targeted.

**Habitat Restoration and Mitigation**

Habitat restoration and mitigation project effectiveness monitoring has been increasing in recent years, but there is room for substantial improvement. There are a number of articles and reviews that assess the effectiveness of particular types of restoration or mitigation projects.

For example, in a review of 345 papers on effectiveness of stream rehabilitation techniques, Roni et al. (2008) found that reconnection of isolated habitats, rehabilitation of floodplains, and placement of instream structures have proven effective for improving habitat and increasing local fish abundance under many circumstances. Techniques that restore the natural processes which create and maintain habitats, such as riparian rehabilitation, sediment reduction methods (road improvements), dam removal, and restoration of floods, are more likely to be effective over long time frames, but little or no long-term monitoring has been conducted on these techniques. When instream restoration projects fail, it is most commonly the result of inadequate assessment of watershed processes and factors limiting biotic production, or lack of consideration of upstream or watershed-scale factors that influence the outcome of reach or localized rehabilitation projects, and insufficient monitoring and evaluation of adequate temporal and spatial scales (Roni et al. 2008).
Reviews of wetland mitigation project effectiveness have been conducted within Washington State and elsewhere. A Department of Ecology study of wetland mitigation found that of 45 projects, only 13 implemented their projects as planned and met their performance standards (Johnson et al. 2000). In the past 10 years, surveys of wetland and stream mitigation projects in King County found that 75% of projects did not meet performance standards (Mockler et al. 1998). Johnson et al. (2002) found that only 65% of the total acreage of wetlands lost in Washington State were replaced by created or restored wetlands.

Within marine habitats, eelgrass transplant projects have been assessed (see Williams and Thom 2001). Transplant success has been increasing as measures have accounted for controlling factors such as light and depth. Avoiding and mitigating for eelgrass impacts has also been studied within Puget Sound, particularly in conjunction with Washington State ferry facility projects. There is inconsistency in level of effort in the restorative actions and assessment of success, which renders comprehensive evaluation of success rates problematic.

As these examples show, there is project performance monitoring information, both for habitat structure and resulting functions. However, scientific certainty about project results is difficult to attain as projects differ in what they examine, how they collect data, and the time over which the project is studied. Projects also are undertaken under very different ecosystem conditions and are not considered comparable.

**Scientific Principles Underpinning Ecosystem Protection and Restoration**

In making its observations about the status of habitat in Puget Sound, the Land Use and Habitat Protection/Restoration Topic Forum team was cognizant of several scientific principles about ecosystem protection and restoration which are worth repeating here. They include:

- Restoration efforts must focus on landscape-scale ecosystem processes, such as the delivery and movement of water, sediment, wood, and nutrients, and the relationship to reach scale processes and functions, as the basis of complex, high quality habitats and diverse, self-sustaining biological communities (Goetz et al. 2004; Beechie and Bolton 1999). Addressing the factors that impact ecosystem processes is critical for restoring habitats and ecosystem functions.

- Freshwater, estuarine, marine and terrestrial habitats are dependent on natural disturbance regimes. Ecosystem restoration needs to recognize natural variability and the role, rates, magnitudes, and locations of natural disturbances in renewing structure and supporting ecosystem functions (Reeves et al. 1995; Goetz et al. 2004; Hobbs and Norton 1996; Wissmar and Bisson 2003; Hood 2007).

- Restoration of ecosystem processes and functions depends on addressing problems within the appropriate time and spatial scales. Functions of particular areas depend on hydrologic, geologic, and topographic conditions (Goetz et al. 2004; NRC 2001). Restoration goals need to be compatible with these natural characteristics of the landscape (Beechie et al. 2003; Roni et al. 2002).

- The probability of a restoration action working is highly dependent on the landscape and site conditions. For example, if a disturbed site sits within a landscape that is intact, restoring the site will likely be more successful because the site will benefit from the surrounding intact landscape processes. Further, the site will be maintained in the long term because the landscape is intact (Figure S2-1; Thom et al. 2005).

- The distribution and array of habitats is a critical factor in determining the viability and health of plant and animal populations. The natural mosaic of habitats in the landscape represents both the culmination of physical and biological processes, and also the structure that animals are adapted to use. The flow of energy, materials, and species among the habitats is critical to resilience of populations, maintenance of biodiversity and self-maintenance of the ecosystem (Thom 2000).

- Protecting ecosystems by avoiding impacts is the best approach to ensure long-term integrity of ecosystem processes and habitat conditions. Protecting areas with high ecosystem integrity, especially those with documented
critical or important ecological functions in the landscape, assures the continued contributions of these areas to the ecosystem. Protection involves minimizing human stressors on existing processes, habitat structures, and ecosystem functions. Restoring habitat conditions is also an important strategy to employ, but is often less certain than protection and is usually more costly. However, in many areas restoration and other habitat improvements will be necessary to achieve desired ecological functions and values.

![Figure S2-1](image_url)

**Figure S2-1: Different restoration strategies** should be applied depending on the level of disturbance at the landscape and site scales (Thom et al. 2005; Shreffler and Thom 1993).

- Restoration of ecosystem processes should be prioritized for areas key to maintaining downstream aquatic ecosystems. Many lowland areas of Puget Sound have been significantly but not permanently altered (e.g., rural areas). Processes in many of these lowland terraces and valleys support the structure and functions of aquatic habitats (i.e., riverine, estuarine, nearshore). As these areas develop, watershed-based restoration and development (i.e., using smart growth measures) in key areas will be essential to minimizing ecosystem impacts.

- Mitigation should be sited and designed within a watershed context. Most mitigation is developed using an environmental review and assessment process that considers primarily site- and reach-scale conditions. National and state mitigation policies require mitigation sequencing which emphasizes avoidance, redesign or on-site mitigation. This has resulted in the creation of atypical habitats (e.g., wetlands with large areas of open water) with an overall loss of performance of functions. Locating mitigation in areas with a higher priority for restoration (e.g., areas with intact or minimally disturbed ecosystem processes) will result cumulatively in a greater net gain of function.

- Monitoring and adaptive management (i.e., using monitoring information to determine effectiveness and making changes in policy and strategies where desired goals are not being met), is critical to achieving ecosystem improvements. Adaptive management, if implemented properly, can reduce cost and increase effectiveness of actions. To date, there is no comprehensive adaptive management program for restoring Puget Sound. However, guidance documents have been prepared by the Puget Sound Nearshore Ecosystem Restoration Partnership (Thom et al. 2007), and for watersheds (e.g., Monitoring and Adaptive Management Plan for Puget Sound Chinook Salmon). Once established, an adaptive management program can provide direct benefit to improving our understanding of how to best and most efficiently restore Puget Sound.
References


Mockler, A., L. Casey, M. Bowles, N. Gillen, and J. Hansen. 1998. Results of Monitoring King County Wetland and Stream Mitigation. King County Department of Development and Environmental Services. King County, WA.


Richards, C., Johnson, L., and Host, G. 1996. Landscape-scale influences on stream habitats and biota. Canadian Journal of Fisheries and Aquatic Sciences 53 (Supplement 1).


Policy Question 1 (P1): What policy approaches are being used to address land use management relative to habitat protection and enhancement in the Puget Sound region?

This paper contains a summary of the tools that exist relative to protecting and/or restoring “ecosystems.” However, it omits specific information being covered by other Topic Forums such as water quantity, water quality, biodiversity, toxics, public health, and quality of life, which might normally be found in a discussion about habitat and land use.

Introduction

In creating the Puget Sound Partnership, the Legislature determined that the scope of what it would be charged with protecting and restoring wasn't simply habitat, but rather the Puget Sound ecosystem. (See RCW 90.71.300.) Accordingly, we examine the tools available to protect and restore Puget Sound using an ecosystem approach.

The term “ecosystem” means the sum of ecosystem processes, structures and functions that occur across the landscape, shaped by the geomorphology of an area. (See Response to Question S1 for more details). An “ecosystem approach” recognizes that ecosystem components do not function as independent systems, rather, they exist only in association with one another. In Puget Sound, the ecosystem includes terrestrial and aquatic (freshwater and marine) systems, all existing in association with one another.

From this ecosystem perspective, we will first examine the framework of laws and regulations that control the human activities in Puget Sound, in light of the major threats to ecosystem processes and habitats described in this report. Second, we will summarize the various voluntary programs and laws that exist in an attempt to influence (rather than mandate) the ways in which humans conduct activities, so that ecosystems are protected, restored or not further degraded. These programs and laws include incentives, education, and stewardship programs. Third, as we discuss these tools, we will identify gaps, where known, where no controls or programs exist to protect the ecosystem or key components of it. Finally, we will discuss the need for one additional tool: a strong monitoring and adaptive management program that continually informs decision-makers about the state of the ecosystem and whether the controls and programs used to protect and restore it are working effectively to achieve and sustain a healthy Puget Sound by 2020.

Controlling the Impacts of Human Activities on Puget Sound through Regulation

The threats that human activities pose to the health of the Puget Sound ecosystem (marine, terrestrial and freshwater aquatic systems) are documented in the Response to Question S1, as well as other Topic Forum reports. There are many regulatory programs (federal, state and local) that attempt to control these impacts. These programs will be described in detail below in two sections: terrestrial/freshwater systems and marine systems. The limitations of these regulatory programs are detailed in Response to Question P2.

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Given the complexity of the regulatory systems that this paper will attempt to describe in a short summary, it is worth highlighting a few key points at the outset:

- Regulation of the environment is largely a new phenomenon which began in the 1970s, but impacts to the Puget Sound ecosystem have been occurring since the beginning of mass migration and settlement in the West in the 1800s.
- Legislators have tended to enact regulations that fix specific problems or focus on specific activities, and to vest authority to regulate in many different agencies (federal, state and local governments). This has sometimes created multiple layers of regulations or, in other cases, created a fragmented system of regulations that doesn’t take into account the need to protect the entire spectrum of ecosystem processes, structures and functions.
- Most regulations aren’t designed to address habitat protection at an ecosystem scale. Many regulations focus on controlling impacts from individual actions taken on specific sites. This can result in the disruption of ecosystem processes.
- The effectiveness of any regulation at achieving the protection sought is influenced by many factors including funding, political will, the effectiveness of the specific treatments called for in regulations at achieving the outcomes sought, the skill and experience of both regulatory staff and the person attempting to implement the requirements, etc.
- As a result of the limitations of the regulatory programs profiled in this paper, legal and permitted activities can still cause impacts to ecosystem processes, structures and functions even where the people implementing regulatory requirements follow all the rules.
- There is no “silver bullet” regulatory program that exists today which solves all of the problems associated with returning the Puget Sound to a healthy condition.

Regulation of Terrestrial and Freshwater Ecosystems

In order to understand how we reached the complex web of regulatory programs that exist today to control human impacts on the natural environment, we must look briefly at the past. The first set of standardized zoning laws was adopted by the federal government in the 1920s to grapple with the social and environmental stresses afflicting growing cities around the nation. Zoning laws were not viewed as environmental tools, but were mainly designed to address and prevent the effects of “nuisance” activities – air and water pollution, noise and industrial hazards.\(^8\) There was little understanding about the complex interactions of ecological systems and the impacts of human populations on those systems.

Up until the 1970s, when a national environmental movement spread across the country, resulting in the adoption of the federal Clean Water Act, Clean Air Act, and Endangered Species Act (ESA), the protection of environmental resources was largely left to state and local elected officials to deal with on an ad hoc basis.

Although there are many federal laws today that are designed to protect certain natural resources (air, water, individual species, etc.), there is still no comprehensive, national framework that requires the protection and/or restoration of ecosystems as a whole, except in the case of national forest and range lands and where the recovery of endangered species (ESA) are involved. The issue is still dealt with mainly by states and local governments.\(^9\) The result is significant.

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\(^8\)Growing Smart Legislative Guidebook, 2002 Edition.

\(^9\)It is interesting to note that unlike water quality, there is no overarching federal law relating to water quantity. Water supply laws vary greatly between the East and West Coasts. This is a legacy of the way in which the West was settled in the 1800s. For more information see the Water Quality and Water Quantity Topic Forum Papers.
From a policy perspective, it is often very difficult for state or local leaders to implement significant changes to land use activities using regulatory approaches in the absence of a major threat to the public health, safety or welfare. It often takes extreme situations (such as the Cuyahoga river fire in Ohio) to provoke public sentiment to the point where a political movement begins calling for more protection of the environment. After these movements subside, the political pendulum can often swing in the opposite direction over a number of years, as people’s memories of the crisis that provoked the regulation fade, affecting the political will to continue environmental protections when landowners and industries complain about the constraints imposed by protective regulations.

State and Local Regulations

Washington’s local experience has been similar to that of the rest of the nation. Although general police powers were granted to cities, counties and towns by the State Constitution in 1889, the specific authority to engage in local planning wasn’t adopted until 1959 and its provisions were optional. For nearly 100 years, local zoning regulations and building permits were the main tools by which specific activities were either allowed or prohibited across the landscape. During that time the state grew steadily and human impacts to the environment were left largely unregulated.

In the early 1970s, consistent with the national environmental movement, Washington adopted three key environmental laws: the State Environmental Policy Act (SEPA), the Shoreline Management Act (SMA) and the Forest Practices Act (FPA). However, further attempts at statewide comprehensive land use planning failed for a variety of reasons. Today, these three laws remain key tools in environmental protection for Puget Sound, although each of them was designed to be applied on a site or permit application scale, rather than an ecosystem scale. The Clean Air Act, implemented by the Puget Sound Clean Air Agency, also protects air quality and limits discharges of certain pollutants within Pierce, King, Snohomish and Kitsap Counties.

With intense population growth throughout the decade of the 1980s, Puget Sound residents began to feel the resulting impacts on their quality of life and demanded change. This resulted in the Legislature’s adoption of the Growth Management Act (GMA) in 1990 and 1991. Only a few states have adopted such aggressive limits on the spread of growth across the landscape and most, including Washington, are still working through the policy and management questions that arise when local governments try to balance all of the competing needs of their citizens.

The GMA is a regulatory tool to manage and direct growth to certain places, while requiring certain infrastructure to accompany it. The Act requires counties choosing or required to plan under the GMA to establish urban growth areas as a central component of the “bottom up” or locally controlled growth management strategy, with limited oversight by regional appeal boards and the state Department of Community Trade and Economic Development. Conceptually,

10 See Wash. Const. Article XI, Section 11.
12 At the same time that these three environmental overlays were enacted into law, the Legislature considered adopting a comprehensive state-supervised land use regulatory system (the State Land Planning Act), not only because a respected Model Land Development Code was published by the distinguished members of the American Law Institute, but also because Congress, through the leadership of Senator Henry M. Jackson, was on the verge of enacting large subsidies for states that had such legislation. But, when the ensuing oil embargo diverted national attention away from the issue, along with the funds, our State Legislature lost interest in comprehensive land use reform. See, Guidance for Growth, University of Puget Sound Law Review, 16:867 at 870-871; 875-877 (1993).
13 However, it should be noted that recent responses by the forestry industry to ESA and Clean Water Act requirements have led to changes in the Forest Practices Act which provide better protection for fish and other species, and the adoption of HCPs which do provide protection at a broader landscape scale. More information on these efforts is provided in the summary set forth in Appendix P1-1.
14 Chapter 70.94 RCW.
16 See Chapter 36.70A RCW.
urban growth areas (UGAs) are intended for compact, higher density urban development to enable more cost-effective urban services and infrastructure, while conserving open space, rural, agricultural, and natural resource lands by prohibiting urban development outside of the UGA. The necessary corollary to containing urban growth within the UGA is zoning that restricts urban densities and development on the rural side of the boundary. When used well, the Act is a powerful tool for local governments to concentrate growth.

The GMA has undergone a number of legislative amendments since its adoption. Most notably for purposes of habitat protection, the Legislature added a requirement in 1995 that the designation and protection of critical areas (which include wetlands, critical aquifer recharge areas, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas) must be supported by best available science.

Apart from changes to the Shoreline Management Act and Forest Practices Act (discussed below), few other changes were made to the state's land use regulatory scheme throughout the 1990s, although federal ESA listings and new Clean Water Act requirements have had significant impact on land use activities in Puget Sound. Today, cities and counties spend a great deal of staff time working on growth planning issues and meeting compliance deadlines related to GMA. This work has not been without controversy or litigation. In particular, the requirement to protect critical areas has spawned many lawsuits against several counties and cities, and push back from some citizens concerned about their property rights.

In addition to these major regulatory tools, there are a few other development regulations routinely used by many local governments to protect the environment, as well as public health and safety. They include some "older" tools such as zoning, clearing and grading regulations, as well as newer regulations such as stormwater or drainage regulations, comprehensive flood plans, flood hazard ordinances adopted consistent with FEMA regulations, low impact development standards, Built Green programs, or other innovative design regulations. The Washington Department of Fish and Wildlife also regulates some aspects of impact to freshwater rivers and streams through its Hydraulic Permit Approval (HPA) program.

Finally, it is also important to note that local governments and special purpose districts such as ports, water, flood and sewer districts have planning and decision-making powers that can affect, in a positive or negative manner, terrestrial and freshwater resources and important estuarine habitats. Similarly, certain federal and state agencies are land managers with the authority to manage publicly-owned lands which can affect ecosystem processes, structures and functions. For example, the Department of Natural Resources manages state-owned aquatic lands (tidelands and shorelands) which it manages pursuant to the directives found in Ch. 79.105 RCW. Those directives include protecting the environment as well as fostering navigation and commerce. At the federal level, the U.S. Department of the Interior's Bureau of Land Management manages over 400,000 acres of federal lands in Washington State which include forests, rangelands, mountains and beaches, for a wide range of uses. Some of those uses include recreation, livestock ranges, oil, gas and mineral extraction, and conservation. (See Appendix P1-1 for additional information on the scope and authority of the BLM as a federal land manager.)

As noted above, many of these regulatory tools have not been studied for their effectiveness in achieving the results sought at the time of permitting. In addition, many government agencies and other commentators noted that those...
agencies tasked with implementing regulatory programs do not have performance monitoring programs that measure whether habitat protections or mitigation measures required in regulations have been appropriately included in land use permits, and whether those protections or mitigation measures are effectively implemented on the ground. Most jurisdictions report a lack of funding to accomplish those tasks and further lack the staff to monitor whether the protections remain after a period of years (beyond the period where they hold bonds or other security for a project). Finally, many jurisdictions also report a lack of adequate funding for general code enforcement efforts (where activities take place outside of the permitting process).

**Federal Regulations**

Most of the federal regulations that protect terrestrial and freshwater aquatic ecosystems (aside from energy-related regulations) have tended to regulate activities that can cause impacts to water quality (Clean Water Act, 404 permits, 401 water quality certifications, etc.), federal forest lands, (e.g., the Northwest Forest Plan), flooding (e.g., FEMA’s NFIP standards) and particular species (e.g., ESA and various other species-specific laws). A more lengthy description of federal regulatory programs can be found in Appendix P1-1.

The Northwest Forest Plan was created using an ecosystem approach and remains a strong tool for the protection of federal forest lands. In addition to federal forest regulations, two other federal laws, the Clean Water Act and Endangered Species Act, have had particular influence in Puget Sound.

First, although it had been applied to discharges of pollutants from industries for some time, the Clean Water Act’s National Pollutant Discharge Elimination System (NPDES) regulations became applicable to counties and cities with populations of 100,000 or greater in 1995. The NPDES municipal stormwater permit protections now apply to all jurisdictions in Puget Sound with 10,000 or more in population, requiring them to adopt a multi-faceted program to control nonpoint stormwater discharges. This has included the adoption of new local regulations such as grading, clearing and drainage ordinances, as well as pollution discharge prohibitions, and the adoption of inspection and enforcement programs and the compliance with reporting requirements. (Additional details about this program can be found in the Water Quantity Topic Forum Discussion Paper).

Second, with the federal listings of local populations of Puget Sound Chinook salmon, Hood Canal summer chum and bull trout under the Endangered Species Act (ESA) in the late 1990s, and recent listings of steelhead salmon and Southern Resident killer whales, the ESA has had an impact on some activities in this state. The ESA protections now regulate and prohibit human activities that harm those species or habitat important for their life stages. Land use activities which have a federal nexus (such as federal grant funding or require other federal permits) must go through a consultation process to ensure that the activities don’t jeopardize the continued existence of listed species.

Although these ESA listings did not change Washington’s land use law per se, concern over the salmon listings has led to several regional efforts to respond proactively through voluntary changes in land use practices, incentive programs, and significant habitat restoration plans. Many jurisdictions also incorporated requirements to protect listed species into GMA critical areas regulations. All of these efforts have been voluntary collaborations convened by leaders across the region who came together to create plans that would respond to the needs of the listed species, while ensuring a vibrant regional economy.

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22 These include the Timber, Fish and Wildlife negotiations; the Tri-County Model 4(d) Rule Response Proposal – a salmon conservation program; the statewide Agriculture, Fish and Water negotiations; the Northwest Forest Plan; the Shared Strategy for Puget Sound’s creation of the Puget Sound Chinook Salmon Recovery Plan, which was adopted by NMFS; and the Hood Canal Coordinating Committee’s creation of a Summer Chum Recovery Plan.
Turning to the marine environment, the history of regulations described above is applicable here as well. The list of regulatory programs that exist today to protect marine resources at the state or local level is fairly short.

**State and Local Regulations**

The principal tool is the Shoreline Management Act, administered by local governments through local shoreline master programs, which are approved against a set of state regulations by the Department of Ecology.

In addition, the Washington State Department of Ecology adds together all of the local shoreline master programs to form the state’s Coastal Zone Management Plan, which it prepares in compliance with the Coastal Zone Management Act.

The Washington Department of Fish and Wildlife (WDFW) regulates and licenses commercial and sport fishing, aquaculture, and regulates some development activities that potentially alter water flow affecting fish and shellfish through its Hydraulic Project Approval program. In addition, WDFW maintains a list of priority habitats and species (PHS) for which they recommend protection of certain species and habitats. WDFW also administers marine protected areas (MPAs) in Puget Sound within which fishing and harvesting of shellfish and other resources is restricted or prohibited. The Department of Natural Resources (DNR) also manages state-owned tidelands, and regulates aquaculture and shellfish harvesting. The Washington State Parks and Recreation Commission regulates boat use and moorage in marine and freshwater areas associated with the state’s park system.

At the county level, there is very limited local regulation of marine waters beyond the jurisdiction of the shoreline master programs implemented under the SMA. San Juan County is the only county to have adopted limits on the use of jet skis and other personal watercraft off its shores in order to protect local marine life and the public health, safety and welfare.

On a positive note, many Puget Sound counties have created Marine Resource Committees (MRCs) under the guidance of the Northwest Straits Commission. MRCs are citizen-based advisory committees committed to protecting and restoring marine resources. Although their work is advisory in nature, their research and policy recommendations for the protection and restoration of marine areas are important resources for local governments to consider in making changes to shoreline master programs and critical areas protections, and in proposing restoration projects.

Finally, it is also important to note that local governments and special purpose districts such as ports, water, flood and sewer districts have planning and decision-making powers that can affect, in a positive or negative manner, marine resources and important estuarine and marine habitats.

**Federal Regulations**

At the federal level, the regulatory picture is much more complex. As an estuary connected to the Pacific Ocean, Puget Sound frequently falls under a web of federal regulations. Those laws were analyzed by the Pew Commission and U.S. Commission on Oceans pursuant to the Oceans Act of 2000, during two comprehensive efforts to understand the state of our oceans and the effectiveness of the nation’s ocean policy. In its final report, the Pew Commission noted the status of federal ocean governance:

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23 The regulatory programs discussed in this section are summarized in Appendix P1-1.
24 The HPA program is authorized under Chapter 77.55 RCW and WAC 220-110.
25 The list includes fish, shellfish, certain marine mammals (porpoises, gray and killer whales, harbor seals, sea otters, and sea lions), shore birds, and other species.
26 See, Fish and Wildlife Commission Policy 3013.
Governance is a reflection of the knowledge and values of the society that creates it. Our ocean governance needs updating to reflect substantial changes in our knowledge of the oceans and our values toward them since our major ocean laws, policies, and institutions were established.

Not a system at all, U.S. ocean policy is a hodgepodge of individual laws that has grown by accretion over the years, often in response to crisis. More than 140 federal laws pertain to oceans and coasts. Collectively, these statutes involve at least six departments of the federal government and dozens of federal agencies in the day-to-day management of our oceans and coastal resources. Authority over marine resources is fragmented geographically, as well. The Submerged Lands Act of 1953 gave most states authority over submerged lands and overlying waters from the shoreline out three miles. Federal territorial sovereignty extends 12 miles offshore, and consistent with the United Nations Convention on the Law of the Sea, the federal government controls ocean resources out 200 miles or more. The federal/state division of ocean jurisdiction makes it difficult to protect marine ecosystems because it divides their management into a nearshore and an offshore component with insufficient means or mandate to harmonize the two.


In its final report, the U.S. Commission Ocean Policy similarly made significant recommendations that would enhance the protection and governance over marine resources and oceans both within the U.S. and internationally. The Final Report is entitled *An Ocean Blueprint for the 21st Century* (U.S. Commission on Ocean Policy, Washington D.C., 2004). A summary of the critical actions they recommend is set forth in Response to Question P2.

### Influencing Human Activities: Incentives, Education, Stewardship and Restoration Programs

There are currently numerous incentives, education and stewardship programs available in Washington State that may influence human activities in a way that results in positive outcomes for the environment. A summary of those programs is set forth in Appendix P1-2. It should be noted that this is not an exhaustive list and there may be programs which should be added. With regard to incentive programs, these are activities that provide landowners with benefits that in turn, induce them to protect or restore the ecosystem processes, structures and functions on their land.

Landowner Incentives Programs include: (1) Direct Financial Incentives (grants, subsidized loans, cost-shares, leases); (2) Indirect Financial Incentives (property tax or sales tax relief, such as Public Benefit Rating System programs); (3) Technical Assistance (referrals, education, training, design assistance programs); and (4) Recognition and certification for products or operations.

Puget Sound has a history of success with implementing landowner incentive programs. For example, many Conservation Districts throughout Puget Sound have been quite successful in working with rural landowners and farmers to create and implement individual farm plans. As a result, landowners and farmers have planted and fenced stream buffers and reduced the introduction of nutrients and pathogens to downstream aquatic ecosystems. Another successful tool is the Public Benefit Rating System program (PBRS), a form of indirect financial incentive. This tool is available today under state law, and has been proven effective in protecting critical habitats in urban and rural areas. For example, King, Clark and Whatcom Counties have used the voluntary PBRS program to reduce property taxes in exchange for a landowner granting protective habitat easements and/or restoring habitat on private property. However, despite this success in implementation, there isn't much data or studies that show whether these programs are achieving the environmental outcomes sought.

Conservation Markets encourage the sale of conservation products or credits from private land. Few examples exist for these types of incentives outside of wetland banking, although interest in these programs is growing. (See, e.g., the Ecosystem Services Marketplace program, an innovative water quality trading program designed to reduce stream
temperatures in the Willamette Basin; and Green House Gases (GHG) emission cap and trade programs being discussed across the nation.)

Stewardship Programs use land sales or exchanges, conservation easements, transfer or purchase of development rights. Acquiring property has the potential to provide long-term protection to habitat resources from a variety of risks. Public agencies, as well as non-governmental organizations such as land trusts and conservancies, often acquire property in one of two ways: acquire the entire property through a fee simple transaction, or, acquire a portion of a property’s rights by either stripping the property of its development rights or acquiring a conservation easement with associated long-term deed restrictions and covenants. Successful examples of such stewardship programs include the Cascade Land Conservancy’s acquisition efforts through its long-term protection plan known as the Cascade Agenda, and the King County and Snohomish County Transfer of Development Rights/Purchase of Development Rights Programs.

Education Programs include public and private outreach and education programs, which are either passive in nature (where a resident simply receives information in the mail or at an event), or active (where training occurs with the expectation that a person will volunteer to protect or monitor some portion of the ecosystem or the health of a species). There are many natural resource education programs designed to be taught in K-12 schools (e.g., education programs designed by state agencies such as WDFW or counties under their NPDES permit programs, and private programs such as Salish Sea Expeditions). There are programs for adults, as well, such as beach-watcher and beach seining volunteer organizations for salmon recovery; watershed-keeper education programs and the like. These programs may result in long-term volunteer engagement in efforts to protect and restore local aquatic systems; however their effectiveness has yet to be measured on a comprehensive scale.

Other Voluntary Efforts
Habitat Restoration Projects take place on public and private properties. Restoration project scale is often a function of project objectives, available funding, and property ownership. Effective restoration of aquatic and terrestrial resources results when a restoration project site is identified, through a technical planning process, to be functionally and physically connected to other ecosystem components. A commitment to monitoring and adaptive management strengthens the likelihood of achieving ongoing restoration project objectives. A variety of local, state, federal, and multi-jurisdictional plans provide guidance as to where habitat restoration projects should take place to achieve specific functional habitat outcomes. There are many habitat restoration plans or guidance documents in existence within the Puget Sound region. They include the various recovery plans adopted by NMFS and USFWS for ESA-listed species; U.S. Army Corps Ecosystem Restoration Plans; plans prepared by the Department of Natural Resources; and projects funded by the Recreation and Conservation Office (RCO) and Marine Resource Committees. In addition, many local governments have adopted natural resource restoration plans.

Watershed Planning Efforts have mainly resulted from the ESA listings of various salmon species. Planning is authorized under Ch. 39.34 RCW (funding watershed management plans), RCW 76.09.350 (landscape planning), and Ch. 90.82 RCW (watershed planning). Some of these voluntary efforts have led to successful adoption of recovery plans, including the Chinook Salmon Recovery Plan and Hood Canal Summer Chum Recovery Plans. The Washington Biodiversity Conservation Strategy is another example of ecosystem-scale planning for species biodiversity. (For more information on biodiversity issues, please refer to the Species, Biodiversity, and the Food Web Topic Forum Discussion Paper.)

In summary, there is a broad array of incentive, education, stewardship, and local planning programs that can be used to protect and restore the environment, and that have a history of success within Puget Sound. However, the tools have not been widely used, nor has their effectiveness been studied or documented. Due to time constraints for development of the Action Agenda, the Land Use/Habitat Protection and Restoration Topic Forum was unable to study each tool to determine which set of programs may provide the best outcomes in each Action Area across Puget Sound, depending on local circumstances. However, we believe that the potential for these programs may be substantial, and it has been largely untapped up until now.
Policy Question 2 (P2): Using the S1, S2, P1 results and risk analysis provided by NOAA, what needs to be done to address the documented threats to habitat from land use practices in the Puget Sound region?

In answering Question P2, the Land Use/Habitat Protection and Restoration Topic Forum has considered the scientific studies and literature cited in the Responses to Questions S1 and S2, the regulations and incentives available under federal, state and local law and programs described in Response to Question P1, as well as our collective professional experience and judgment. We were not able to consider the NOAA risk analysis in our work because it was unavailable.

Introduction

Our system of protecting the environment wasn’t designed to protect the entire ecosystem of Puget Sound. Instead, it often prioritizes the human consumption of ecosystem goods and services over the protection of ecosystem-forming processes, structures and functions that provide or support many of those goods and services. We protect components of the system, but not the entire ecosystem. This report presents an analysis of the gaps and limitations existing in the protection and incentive tools that exist today in Puget Sound. It makes recommendations for fundamental changes that will challenge the commitment of policymakers, scientists and most importantly, our citizens, to our goal of a healthy Puget Sound. It is intended to provoke and inspire a community discussion, debate and critical thinking about what is possible if we are to achieve our goal by 2020.

Gaps and Limitations of Our Management Tools

As noted in the Response to Question P1, Washington's tools have developed over many years, driven by different issues. Although there are many tools available that can be used to protect some portions of the ecosystem, there is no “silver bullet” that will solve all of our concerns. GMA has proved to be an important tool for managing growth, not halting it. Even if it did, existing impacts of prior development and land alteration from human activities remain. Because regulations typically only address new development, improving the regulatory system for new development doesn’t address this problem. A robust restoration program will still be needed to ensure the success of our efforts.

In order to take the next step forward in protecting Puget Sound, we need a specific examination of the limitations presented by our management tools. The following is a short summary of some of the criticisms that have been levied about them, when viewed in the context of protecting marine areas or terrestrial and freshwater systems from an ecosystem perspective.

Marine Areas

A myriad of federal regulations apply in marine areas, leading to conflicting institutional oversight. Regulations have focused mainly on the exploitation of resources to the detriment of marine life. Inadequate attention has been given to the protection and restoration of the ecosystem processes, structures and functions needed for survival.

At the state and local level, there is a burgeoning of beneficial programs and regulations, especially in recent years (for example, MRC research and policy developments, landowner incentives, marine protected areas, Shoreline Management Act, SEPA and GMA). However, there is no comprehensive Puget Sound-wide ecosystem plan for protecting and restoring marine life and marine areas, including the nearshore. As we seek to improve our protection strategies, we should consider spending more time analyzing not just how a regulatory program could work to protect marine drift cells through an ecosystem approach, but also which voluntary incentive tools can be effective in protecting them as well. Although voluntary programs enjoy wide public support, such programs have not been planned, promoted or funded in a comprehensive way in Puget Sound. We believe these programs have good potential when coupled with regulatory protections to provide positive outcomes for both the environment and for people.
Terrestrial and Freshwater Aquatic Systems

Puget Sound’s health and species use are greatly affected by the condition of its terrestrial and freshwater ecosystems. Historically, federal, state and local approaches were aimed mainly at in-water effects of land use activities – an ecosystem perspective was lacking. More recently however, federal agencies have implemented ecosystem approaches through such actions as the Pacific Northwest Forest Plan (1994) and implementation of the federal Endangered Species Act, which explicitly calls for protecting listed species and their ecosystems. Arguably, the federal approaches are still being refined and there is much to learn, but they represent significant initial efforts to manage at the ecosystem level. State and local approaches have a similar history and are lagging behind the federal approaches.

Recently, Washington State has engaged in ecosystem-based approaches include the Forest and Fish Agreement and the SMA update process. In addition, the WDFW and Tribes created comprehensive management plans to address impacts to wild salmonids from hatcheries and recreational and commercial harvest activities. Local governments are behind farther still, but significant gains are being made at that level, too. While historically, most governments have not pursued such comprehensive environmental planning, many have recently done so as part of the WRIA-based salmon recovery plans. These recovery plans are focused on ESA-listed salmon, mainly Chinook and chum salmon, but they provide a helpful template for assessing and understanding land use impacts on fresh and marine systems.

Typically, the least developed aspect of these plans is the linkages between fresh and marine waters and the role of healthy marine habitats, especially nearshore habitats and processes, on salmon recovery. This reflects the relatively immature state of our knowledge about the functions and values of marine nearshore environments; much of this knowledge deficit is being addressed by a wide variety of studies. However, the management of habitat, harvest, hydropower and hatcheries (the so-called 4-H’s) is not well-integrated at the WRIA level and an “H-Integration” process is underway to ensure that (a) the local role of all the H’s is understood; (b) actions related to recovery actions are not working at cross-purposes; and (c) actions are sequenced properly and strategically to achieve the best environmental outcomes. Given the role of salmon as a keystone species in the Pacific Northwest, these WRIA plans represent a good start at addressing ecosystem needs of the Puget Sound.

Finally, as to the availability and use of voluntary incentive programs in terrestrial and freshwater areas, the same comments apply here as stated in the previous section.

Limitations of Specific Regulatory Tools

The Growth Management Act

Because the Growth Management Act (GMA) is a management tool of widespread applicability, both geographically and substantively, in controlling the impacts of growth and development in Puget Sound, we single it out for special analysis.

The GMA has fundamentally changed the way that growth is dealt with in Washington. Growth (seen as new development for housing, jobs, recreation, other infrastructure and amenities) is now channeled into urban growth areas (UGAs). Outside UGAs, the Act restricts growth to prevent negative impacts on rural character and the environment. While these changes are great improvements over the era of unrestricted growth prior to the adoption of the GMA in 1990, implementation of the Act hasn’t always been easy, nor have local governments always understood the long-term implications of their planning choices. GMA is not designed to slow the overall pace of the region’s growth as a whole.

27 For example, from the mid-1980s to late 1990s, King County developed several comprehensive Basin Plans to deal with habitat, flooding, erosion and water quality issues. These plans have affected zoning, stormwater, and habitat protection and restoration and they often provide the basis for many actions being developed for salmon recovery within the county.

28 We should note that the terms “urbanization” or “urbanizing” are frequently used as shorthand to refer not just to growth densities as defined under GMA, but to the host of human impacts that are seen as threats (or stressors) on ecosystem-forming processes, structures and function. In this summary, we intend the term to have its GMA meaning.
or limit habitat alteration (such as the loss of forest cover) outside of critical areas. In some jurisdictions, the private market has quickly adapted to new restrictions and people have found new opportunities to exploit available land in ways that were unforeseen. The reality is that with only 15 years of experience making public policy under GMA, local governments are still learning how to improve growth management at the local level.

This is particularly true in the area of rural land management. The continued rate of development in rural areas is a concern. In the four-county region encompassed by Puget Sound Regional Council, rural development ranges between 4% and 45% of the population growth. Although the trend in rural growth rates is downward from pre-GMA days, the potential for significant rural growth is still present given historical lot parcelization patterns in some areas and zoning in other areas that allows lots less than 10 acres in size (some as small as 1 and 2 acres).

Development in rural areas presents a concern for the ecosystem because it is in those rural areas where high-quality habitat and significant ecological processes remain partially or largely intact. The concern is that rural area forest cover is being converted to housing and other uses in 5-acre and smaller patchwork patterns at a fast pace. The network of infrastructure (primarily roads, but also other utilities) constructed to serve such development will further fragment the landscape and interrupt or modify the delivery, movement and storage of water, sediment, woody debris and migrating species.

There is also practical limitation in the GMA that has left some of its goals unrealized: Although state agencies such as CTED have the ability to review and comment on local ordinances before they are adopted, state agencies lack the authority to approve or deny proposed plans and regulations. Instead, citizens and state agencies must rely on an appeal process before the Growth Management Hearings Board (GMHB) and further appeals to court if they are not satisfied with the result. Appeals don’t always freeze the status quo during the litigation process. Even where an action is challenged and later invalidated by a hearings board on appeal, savvy developers may vest a complete application and secure rights to build under the local government’s action taken in contravention of GMA, if done before the act is invalidated. Where no appeals are filed, the GMHB has no jurisdiction to review a local plan or regulation adopted under GMA. This has added to the variability of protection afforded to the ecosystem across the Sound.

In addition, large-scale regional planning which could increase consistency and coordination in land use planning has yet to occur in the entirety of Puget Sound. Solid regional planning efforts, such as the Puget Sound Regional Council and the Thurston Regional Planning Council, don’t exist outside of the counties participating in those efforts.

SEPA
Although SEPA was originally envisioned as a powerful tool to provide environmental protection, it has become a tool that provides information, rather than one that mandates specific environmental outcomes. Thus it is largely an ineffective tool in ensuring the best outcomes for Puget Sound. This is a result of regulatory reform efforts made during the 1980s and 1990s.

Other Development Regulations
When local regulations require mitigation of environmental impacts, those regulations generally do not require cumulative impacts to be addressed. This is in part due to statutory and constitutional limitations that limit a developer’s responsibility for mitigation only to the direct impacts resulting from their activities. In addition, the “no net loss” standard for the protection of critical areas functions and values is not being met, and is unlikely to be met without

29 It should also be noted that non-traditional management tools exist as well. The Puget Sound Regional Council provides a regional planning framework for King, Snohomish, Pierce and Kitsap Counties under GMA. They develop and adopt joint planning policies, such as Vision 2040, which can lead to better coordination and outcomes for growth management among the participants. While not a “management tool” in the sense that the group is not a regulatory agency, the policies do matter. (For example, each participant’s transportation plans must be consistent with the latest adopted PSRC planning policies or they will not achieve approval from PSRC, which has consequences).
significant investment in comprehensive ecosystem restoration that transcends effects that occur beyond parcel boundaries. In part, this is because every jurisdiction in Puget Sound that has adopted critical areas regulations (and other development standards) offers numerous exemptions and compromises that allow for priority human activities and uses, such as road and bridge crossings over streams, ongoing agriculture, and vested lots with development potential.

Other Factors
All of the tools mentioned are limited by the laws that enact them, as well as other factors. Examples of these “other factors” include legal rights granted to various people through laws and legal entitlements. Examples of such factors include Washington’s generous vesting laws\(^{31}\), licenses, leases, or treaties that grant the right to extract or consume natural resources or species such as mining or shellfish leases owned by some landowners, legal, nonconforming uses and preexisting development built in earlier years without adequate environmental protections or mitigation, and constitutional limitations (i.e., the takings clause and substantive due process) afforded to people under state and federal laws. These factors naturally limit the effectiveness of new regulatory tools designed to protect the ecosystem, because they authorize or excuse activities that may cause stress or impact to the ecosystem. These factors, like others, highlight the inherent limits of using regulatory tools and the need to use alternative approaches (such as voluntary incentive programs, acquisition of property rights through easements and purchases, and education) to achieve protection and restoration.

ESA Listings
Federal listings of species have resulted in watershed (WRIA) recovery plans that address reach and watershed-scale conditions and processes. These plans are at various stages of early implementation, mostly focused on capital projects to protect and restore habitat. Prior to these plans, and still ongoing, are additional protections (mainly for the benefit of salmonids) provided by federal regulatory mechanisms such as Section 7 consultation\(^{32}\) or where a Section 10 habitat conservation plan\(^{33}\) is sought to allow activities that may result in incidental take of a species. While these ESA tools afford greater protection and scrutiny on specific listed species and their habitat needs, the listings have not yet resulted in noticeable ecosystem-wide benefits in Puget Sound. There are, however, a few examples of communities that have tried to take more of an ecosystem, multi-species approach to protect habitat against human-induced impacts, especially land development.\(^{34}\) They include the San Diego Multi-Species Conservation Plan (MSCP) and the northern California gnatcatcher conservation plan.\(^{35}\) These plans could prove useful as models for the creation of the Action Agenda, in terms of understanding the way in which scientists and policymakers worked together to make informed decisions to manage large ecosystems, and the tools that they used to accomplish the plans, monitor and adapt them over time.

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31 The vested rights doctrine is a legal concept that protects a developer from having to comply with later-enacted changes in land use regulations. Washington’s vesting doctrine grants such rights at the time that a developer files a complete permit application. The doctrine was created to protect a developer’s investment expectations against fluctuating regulations (which people usually presume will be more stringent). Washington’s vesting laws are commonly called “generous” because they “freeze” the land use control regulations that may be applied to a permit application at an earlier time than virtually any other state in the nation. Washington’s vested rights doctrine runs contrary to the overwhelming majority rule that “development is not immune from subsequently adopted regulations until a building permit has been obtained and substantial development has occurred in reliance on that permit.” Erickson & Assoc. v. McLerran, 123 Wn.2d 864, 868, 872 P.2d 1090 (1994) citing R. Settle, Washington Land Use and Environmental Practice, Section 2.7 (1983)).


34 Although this team did not have the time or resources to study them, some of the HCPs issued for large timber holdings may result in ecosystem benefits, given that they tend to be multi-species in coverage and extend across large areas of land.

35 The southern california plans include: the California Natural Community Conservation Planning Act (NCCP), CA Fish and Game Code, Sections 2800-2835; and San Diego Multi-Species Conservation Plan, http://www.sdcounty.ca.gov/dplu/mscp/
Limitations of Voluntary Programs
Incentives, Education and Stewardship
These approaches address human behaviors and motivations through a combination of material (mostly monetary) incentives and education and involvement; the latter assumes well-informed and involved citizenry will modify behaviors for the sake of the larger system. Potentially, these approaches can provide benefits over and above what regulations and capital projects could provide. Incentive programs are particularly important in addressing the impacts of existing development that the regulatory program is not able to affect. A broad range of programs exist in Puget Sound. A summary is provided in Appendix P1-2. As with any tool, these programs have limits on their applicability and the extent of their reach.

For example, the programs aren’t available for everyone. Even if they were, not all people are motivated by financial gain or altruism. Secondly, given the diversity of people and perspectives in the region, the most willing may not be situated in areas with the greatest need or potential for benefits. Third, these approaches take time, can often be costly to implement and likely require sustained effort over time, all of which are difficult for a government to accomplish. One of the conservation approaches with the most certain outcomes, land acquisition, also has notable complexities. When the purchaser is governmental, it is important to remember that federal, state, and local agencies possess variable conservation missions and publicly-owned land does not always translate to habitat protection and/or conservation. Some agencies prioritize public access, resource extraction, or other land uses that may pose a conflict with certain habitat protection goals. Habitat protection through property acquisition requires a long-term, well-funded, adaptive approach to resource management. Very few land managers and conservation easement holders possess long-term funding certainty for monitoring, maintenance, and resource management.36 Finally, we haven’t performed a comprehensive analysis of which tools are most effective in which situations. Regardless, we believe that these tools have great potential and should be studied further to determine which ones are effective and can be used strategically to provide protections for ecosystem health.

Habitat Restoration Projects
Historically, with regard to publicly funded habitat restoration projects, federal and state-funded projects haven’t required an integrated, ecosystem plan as a prerequisite to construction. Without such a plan, it is likely that restoration projects will be performed in an opportunistic fashion, instead of in a deliberate manner in which projects contribute to restoring or recreating the building blocks of ecosystem processes, structures and functions which will sustain over time. More recently however, the development of WRIA salmon recovery plans has led the Salmon Recovery Funding Board (SRFB) to require projects to be an integral part of a WRIA or similar watershed-based plan.

Implementation of restoration projects even within a landscape context is hindered by an artificial separation between compensatory mitigation and restoration. Local governments will typically not consider listed restoration projects or opportunities as appropriate mitigation for a variety of reasons. This results in most mitigation projects being conducted onsite, even if the mitigation project will result in an overall net loss of function. Currently, resource scientists find that a combination of onsite mitigation and offsite restoration is needed in order to attain “no net loss” of ecosystem function. (See Appendix P2-2.)

Presumably, over time, as restoration and habitat mitigation projects are implemented, they will be better matched to their watershed context and, ultimately, much more successful at achieving the restoration goal. One of the more promising aspects of habitat restoration is the increasing emphasis on restoring natural process, such as by restoring forest cover or removing obstacles to floodplain processes, rather than simply creating overly engineered structures, such as pools or spawning substrates for salmon, in locales that would not historically or can no longer support those structures. Process-based restoration projects are complex, can take longer to plan and carry out and generally require a larger geographic scale to make a significant difference. They can be expensive and proponents are sometimes required to piece together the funding to support the project design, construction, monitoring and adaptive management. However, despite these barriers to moving such projects forward, process-based restoration and

avoidance of artificial, out-of-context structure based restoration will be critical to long-term, cost and biologically effective restoration.

**Conclusion**

The regulatory tools with the best potential to protect or restore portions of the Puget Sound ecosystem are just over 30 years old, and our most comprehensive tool from a landscape perspective, GMA, is newer still. GMA is focused on managing growth, not preventing it. This means that although the region will benefit from this regulatory tool, it may not be effective in avoiding impacts to quality of life caused by ever-increasing population growth, and to continuing ecosystem degradation in areas of highly concentrated populations.

While protecting critical areas and shorelines is included among the regulatory mandates of the GMA, planning was not usually accomplished with ecosystem constraints taken into account before uses and zones were adopted. In addition, land use planning occurs on a jurisdiction-by-jurisdiction basis, with some coordination across cities and counties through countywide planning policies and occasionally on a multi-county scale. The number of jurisdictions involved in making land use decisions that affect a single ecosystem remains a significant issue which must be addressed in Puget Sound, if we are to move away from fragmentation and toward ecosystem protection and restoration.

The effectiveness of any regulation at achieving the protection sought is influenced by many factors including funding, political will, the effectiveness of the specific treatments called for in regulations at achieving the outcomes sought, the skill and experience of both regulatory staff and the person attempting to implement the requirements, etc.

As a result of the limitations of the regulatory programs profiled in this paper, legal and permitted activities can still cause impacts to ecosystem processes, structures and functions even where the people implementing regulatory requirements follow all the rules.

Many of the environmental protection tools that are available in Washington have an effect at the site scale, rather than at an ecosystem scale, often missing the need to protect key ecosystem-forming processes. All regulatory and voluntary, incentive-based tools contain exceptions and limits that reduce the certainty of results needed to ensure the sustainability of ecosystem processes, structures and function for a healthy Puget Sound. Net improvement of the ecosystem has not been the case, which strongly suggests that it may be unachievable under the present political/regulatory framework. There is no “silver bullet” regulatory program that exists today which solves all of the problems associated with returning the Puget Sound to a healthy condition.

What all of this tells us is that regulatory tools have their limits. A “one size fits all” regulation alone will not solve the problems facing Puget Sound. Instead, what decision-makers need is a common set of guidelines from the scientific community stating, to the best extent known, the outcomes regulations need to achieve in order to protect ecosystem processes. Against these guidelines local communities across Puget Sound could perform landscape-scale habitat assessments to understand where ecosystem processes remain intact, are at risk of degradation from human activities, or have been lost and need restoration. Using these landscape-scale assessments, government agencies and citizens can make more strategic choices about where to protect and restore ecosystem processes, structures and function in Puget Sound, and which suite of regulatory and incentive programs will achieve the outcomes described in the scientific guidelines.

Achieving this will take reform and realignment of federal, state and local laws and regulations. While still allowing some variation for local conditions and preferences, this approach will lead to better consistency in terms of environmental outcomes. It could also lead to a permitting program that streamlines multiple layers of review by various agencies with inconsistent goals for environmental outcomes.

Reform for the purpose of providing protection of marine resources and oceans at the national and international levels has been identified and prioritized by the U.S. Commission on Ocean Policy and the Pew Commission. Working together, they now have formed the Joint Ocean Commission Initiative and are now calling on the federal, state and
Recommendations for Achieving a Healthy Puget Sound by 2020

Between 1970 and 2000, Puget Sound grew by 1.3 million people, at an annual average growth rate of 1.8%. The rate was greatest during the 1980s at 2.1%. The region's job base more than doubled during the same period, rising from about 760,000 to 1.9 million. The regional job growth rate averaged 3.1% per year, a full percentage point higher than the national average.

During the same period, human activities that threatened Puget Sound proceeded within a fragmented regulatory context where (1) governance was divided among hundreds of federal, state, local, and tribal governments; (2) consumption of natural resources accelerated, with economic goals often outweighing environmental protection; and (3) protection outcomes often differed or conflicted from agency to agency. While generally accepted by the public, voluntary programs have suffered from the same fragmentation in governance, protection and/or restoration goals and environmental results. Finally, until relatively recently, these laws and programs have been generally applied at a site scale, often without regard for the site's value and relationship to the larger context of ecosystem processes, structures and functions.

The result of this historically fragmented system is a Puget Sound ecosystem in serious decline and with an uncertain future. Regional planners tell us that between 2000 and 2040, the region is forecast to grow by an additional 1.7 million people, increasing 52% to reach a population of 5 million. The region's job base is expected to grow to more than 3.1 million, an increase of 64% during the period. If we are going to continue to grow, we must do so in a manner that is smarter and more strategic than we have done in the past.

Given what we know about ecosystem processes, structures and functions, and the tools we have used to control human impacts to the ecosystem, the Topic Forum concluded that: In order to achieve the goal of a healthy Puget Sound by 2020 and support the predicted growth in people and jobs, this region needs a fundamental change in the way in which it manages natural resources and the human activities that impact them. We believe these fundamental changes must achieve three outcomes: (1) a clear statement of the ecosystem processes, structures and functions that must be protected to sustain Puget Sound over time; (2) a consistent set of policy goals that will lead to a sustainable Puget Sound ecosystem; and (3) a governance structure charged with and capable of ensuring that the policy goals are being met.

The following are the recommendations developed by the Land Use/Habitat Protection and Restoration Topic Forum based on the work of the team, the comments received at the public workshops and other public comments received, for consideration by the Puget Sound Partnership during its upcoming discussions on the creation of the Action Agenda.

Science and Research Preliminary Recommendations

1. Create a clear science framework and baseline information from which to act and measure progress.

   - Perform a rapid, landscape-scale assessment across Puget Sound of the status of ecosystem processes, structures and functions. Using the best science and research known today, we recommend that a Sound-wide effort be undertaken over a period of 12-24 months to perform landscape-scale assessments identifying the status of important ecosystem processes, structures and function within marine drift cells and in the terrestrial and freshwater aquatic catchments in Puget Sound. The results of such a rapid assessment will improve our

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37 Vision 2040, Puget Sound Regional Council, February 14, 2008 at p. 5.

38 Id.
knowledge in these areas and allow near-term, strategic efforts to protect and restore the ecosystem. The assessments should examine (1) the present condition of marine drift cells and watershed catchments within each Action Area (or whatever scale of assessment is determined to be most appropriate); (2) the land use policy decisions that have been made that may impact these areas; and (3) the areas that should be prioritized to preserve and restore ecosystem processes, structures and functions. This work will help inform policymakers and scientists needing to make strategic decisions about which areas need urgent action first. It will provide information about the character and rarity of habitat types, where they are spatially in relation to one another, and where threats are present which pose risk to the ecosystem processes, structures and/or functions. This information should also be provided to the NOAA Integrated Ecosystem Assessment science team for their consideration. [Note: An abbreviated Case Study of eastern Jefferson County was performed by the Land Use/Habitat Protection and Restoration Topic Forum in order to demonstrate how such a rapid assessment can be done. It is attached to this paper as Appendix P2-4.]

- Perform a comprehensive species natural history survey. A major limitation in achieving a clear science framework from which to act is the lack of a comprehensive natural history survey for Puget Sound. Such a survey would provide biological information on spatial and temporal distribution of its species and biological communities, which are both a primary resource, and which serve as an indicator of health for Puget Sound. Identify what species are or should be present; plan for their needs and translate that information into site scale protections. [For more information, see the Species, Biodiversity, and the Food Web Topic Forum Discussion Paper.]

- Perform a comprehensive/credible study of the cumulative effects of multiple stressors on the ecosystem.

- Until a cumulative effects study is complete, create and use an additive model and uniform, qualitative descriptors to assess the status of Puget Sound Ecosystem (i.e., use an additive model) and use more qualitative descriptors of the system state. (See, e.g., eastern Jefferson County Nearshore Assessment (Diefenderfer et al.) and the Birch Bay watershed assessment (Stanley et al.).)

- Consider the conclusions of the NOAA Integrated Ecosystem Assessment for Puget Sound. As this work becomes available, it should be added to the existing scientific knowledge to form the science framework within which we act to restore Puget Sound.

2. Implement a strong monitoring and adaptive management framework to ensure that the Action Agenda achieves the results it seeks.

A critical part of the creation of a monitoring and adaptive management program will require the development of a common methodology for monitoring that is rapid, replicable and whose results can be readily interpreted and used by local governments and other actors at the watershed scale. It is recommended that as a monitoring framework for Puget Sound is created, status and trends monitoring protocols should be developed as an early action item so that other monitoring work that is already underway can be aligned with it.

3. Close our knowledge gaps through the adoption of a robust scientific research agenda.

A comprehensive list of needed scientific research studies should be created and pursued by the Partnership and its partners (both public and private) in order to fill the gaps in scientific understanding described in this paper. Some of these gaps in understanding include:

- How nearshore and watershed processes affect the structure and function of freshwater, nearshore/marine ecosystems.

- How human activities affect freshwater and nearshore processes, structure and function. (See goals 1 and 2 in Gelfenbaum et al. 2006.) This includes a better understanding of how deep water habitat processes in Puget Sound may be affected by future development such as further shoreline modifications, wastewater discharge, and energy generation (see Beechie et al. 2007).

- The cumulative effects of multiple stressors on processes and habitat structure and function (see above).
4. Establish a scientifically based strategy to choose restoration projects based on probability of success.

The location, type and extent of projects should be chosen consistent with site and landscape context and condition. For example, sites with a high degree of disturbance on both scales, in general have a low probability for restoration (in the scientific sense of returning an area to a semblance of its pre-development condition). Instead, creation of a new habitat or ecosystem, or enhancement of selected attributes, would be the most viable strategies to apply in these situations. In contrast, where the site and landscape are largely intact, restoration to historical (i.e., humans present, but insignificant disturbance) or pre-disturbance (i.e., before human) conditions would be viable options and the probability of success would be high. (See Figure P2-1.)

5. Use a common philosophy to choose areas that require restoration of key processes.

The Topic Forum recommends prioritizing restoration of ecosystem processes for areas key to maintaining downstream aquatic ecosystems. Many lowland areas of Puget Sound have been significantly, but not permanently, altered (such as in rural areas). Processes in many of these lowland terraces and valleys support the structure and functions of aquatic resources (riverine, estuarine and nearshore areas). As these areas develop, watershed based restoration and development using smart growth or low impact measures will be essential to achieving no net loss of ecosystem processes, structures and functions. Examples of such project criteria are found in Appendix P2-3.

6. Build upon existing science-based conservation strategies and plans.

The Washington Biodiversity Conservation Strategy and Recovery Plans for Puget Sound Chinook and Hood Canal Summer Chum Salmon, Southern Resident Killer Whales and other species should be incorporated into the ecosystem plan for the restoration of Puget Sound.
Preliminary Policy Recommendations

1. Protection should be the preferred approach to ensuring that ecosystem processes, structures and functions are sustained over time. Where impacts have already occurred in areas that are critical to ecosystem processes, structures and functions, restoration projects should receive top priority for funding and other resources.

   • Establish clear, scientific standards that define which habitat processes, structures and functions are critical for the proper functioning of the ecosystem as a whole, and where impacts to them should be avoided at all costs. Most protective regulations use a hierarchy to guide applicants and permit reviewers in how impacts will be evaluated. The hierarchy usually is stated as impacts should be “avoided, minimized, mitigated or, when all else fails, habitat should be restored.” Clear standards need to be established that state when impacts are to be avoided at all costs, and when the other approaches may be appropriate, based on the ecosystem processes, structures and functions that are present on a given site in relation to the entire ecosystem. This will improve the certainty of environmental outcomes during the permitting process.

   • Select tools that provide the greatest level of certainty of result for the longest duration of time over other protection tools or programs.

   • Prioritize restoration projects. Restoration projects that address impacts to the most important ecosystem processes, structures and functions should receive early attention and funding.

2. The region should discuss its vision for a future quality of life.

   We recommend that the Puget Sound Partnership lead a regional conversation about the projected population growth of our region to 5 million people by 2040, in order to understand its impacts on the quality of life for humans, the ecosystem of Puget Sound and our economy. The discussion should include the concepts of the maximum capacity of the region to accommodate increased population from a quality of life standpoint, and from the viewpoint of the resiliency of the ecosystem to sustain stressors over time. Examples from other communities which have faced similar situations should be studied to provide options for consideration by our state. (For a summary of the concept of “resiliency,” see Appendix P2-1.)

3. The Puget Sound Regional Council’s Vision 2040 plan should be used throughout the Puget Sound region as a model for how to focus growth in a way that will protect Puget Sound.

   The PSRC’s plan supports the preservation of forest and agricultural resource lands; reduces growth levels in rural areas; supports maintaining the current urban growth boundaries; and encourages growth inside the designated urban growth boundaries, especially within designated regional growth centers.

   • The focus should be to minimize land conversion to urban-style uses or intensities outside UGAs and to require best management practices and low impact development standards within resource and rural lands which have the highest value for preservation of habitat and ecosystems that support the health of Puget Sound.

   • Within urban growth boundaries, critical existing ecosystem processes, structures and functions should receive special protection. Where such ecosystem processes do not exist, actions should concentrate on reducing polluted runoff, low impact development standards, and site-specific shoreline clean-up and restoration where it can make a difference.

4. Adopt a consistent set of habitat protection outcomes required to be achieved by all jurisdictions (federal, state or local) permitting land use activities within Puget Sound through a mix of regulations or incentive programs. The protective standard should be applied to all lands and aquatic or marine areas identified as critical to protecting

39 Similar discussions have occurred in other communities which have sought to control growth, including Boulder, Colorado, Petaluma, California and Lake Oswego, Oregon.
ecosystem processes, structures and functions. Realign or replace existing programs or regulations that are either inconsistent or in conflict with the protective standard. Monitor results achieved by each jurisdiction in order to ensure habitat protection outcomes are being met.

In order to streamline permitting, avoid duplicative or conflicting regulatory requirements, and achieve consistent ecosystem outcomes, the Topic Forum recommends adoption of a single set of standards that describe the habitat protection outcomes required to be achieved by jurisdictions (federal, state or local governments) in permitting any land use activities that may affect the ecosystem(s) of Puget Sound.\(^\text{40}\) The basic framework envisioned is as follows:

**Standard:** A standard should be adopted by the state that describes the performance outcomes desired for each of the components of habitat-forming processes, structures and functions of marine drift cells and terrestrial and freshwater aquatic areas. The protective standard should take into account the full range of natural physical and chemical factors that control ecosystem processes, as well as the effects of natural factors such as predation, disease and climate change in establishing protective standards that must be met, either through regulation, incentive-based programs or acquisition efforts.

**Applicability:** The standard should apply to a uniform set of land use, marine use or recreational activities that have been identified as threats (or stressors) to the health of Puget Sound ecosystem.

**Strategies to protect:** Jurisdictions required to meet the protective habitat standard should conduct watershed-scale (or drift cell-scale, for marine areas) assessment to identify the local conditions and where habitats should be protected and/or restored. With input from citizens, local agencies should employ a mix of regulatory and/or incentive-based programs to accomplish the protection (and/or restoration) outcomes described in the state standard. Where protection at the highest levels is desired to protect ecosystem processes, agencies should consider strictly limiting new development or other activities that alter habitat, and should use a mix of incentive-based programs to permanently protect those areas. Where restoration is necessary to return missing habitat processes, incentives or acquisition should be used to restore lands where existing development or other activities have altered it. Regulatory programs that permit development should be designed to take into account, to the maximum extent possible, cumulative effects of human stressors on the ecosystem.\(^\text{41}\) Regulations should limit the expansion or continuation of nonconforming uses beyond the reasonable life cycle of the use.

**What it would integrate:** At a minimum, Washington State agencies with regulatory jurisdiction under the Forest Practices Act, Hydraulic Project Approval program, SEPA, Shoreline Management Act, Growth Management Act, CZMA, and Clean Water Act, should work to identify barriers within state and federal programs, laws or regulations that would need to be realigned, amended or eliminated in order to implement the habitat outcomes described in this section.

**Implementation with accountability requirements:** All jurisdictions (federal, state, local and tribal) with permitting authority over land and marine uses should be required to achieve the state standard established to protect and restore the habitat processes, structures and functions necessary for a healthy Puget Sound. This can be accomplished through a mix of regulation, incentive programs or acquisition efforts. The proper mix would be determined at the local level and monitored by a governing agency or group with final approval authority before the regulations or programs go into effect. Local governments would report permitting activity to the state agency. Monitoring of ecosystem conditions

\(^{40}\) The state laws most often discussed in this context are SEPA, SMA, and GMA. Other state statutes might include the Forest Practices Act and the Hydraulic Project Approval. Federal permits required under the Clean Water Act and the Endangered Species Act present additional challenges. Previous efforts at integrating state laws have foundered for a variety of reasons. For a report on the most recent effort, see the final report of the Land Use Study Commission on a consolidated land use code at www.cted.wa.gov/landuse/report/index.html. One of the issues that the Land Use Study Commission was unable to resolve was the basic governance model. The two basic models in existing state law are exemplified by the GMA and the SMA. (Our governance proposal is discussed in the next section.)

\(^{41}\)See Appendix P2-2.
should be conducted the state or through the region, in consultation with local residents and governments to determine the effectiveness of the regulations and incentive programs, and the extent to which they are being properly implemented and achieving the results sought. The Shoreline Management Act provides an example of how such a program might work.

Successful implementation of a Sound-wide ecosystem-based management plan will require the full participation of the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, NMFS, EPA, Tribal governments and state agencies such as the Departments of Fish and Wildlife, Ecology, Community Trade and Economic Development, Puget Sound Partnership and perhaps others. An appropriate program or mechanism to issue 401 and 404 permits under the Clean Water Act must be created and agreed to by these agencies prior to the development of the plan.

5. At the federal level, the President and Congress should immediately adopt the recommendations of the U.S. Commission on Ocean Policy in its 2004 Final Report.

The recommendations are set forth in the U.S. Commission on Ocean Policy’s Final Report entitled An Ocean Blueprint for the 21st Century. These recommendations address five main challenges: reforming ocean governance, restoring America’s fisheries, protecting our coasts, cleaning coastal waters, and guiding sustainable aquaculture.

Critical Actions Recommended by the U.S. Commission on Ocean Policy
The following key recommendations provide the foundation for a comprehensive national ocean policy that will lead to significant improvements in ocean and coastal management.

Improved Governance

- Establish a National Ocean Council in the Executive Office of the President, chaired by an Assistant to the President.
- Create a non-federal President’s Council of Advisors on Ocean Policy.
- Improve the federal agency structure by strengthening NOAA and consolidating federal agency programs according to a phased approach.
- Develop a flexible, voluntary process for creating regional ocean councils, facilitated and supported by the National Ocean Council.
- Create a coordinated management regime for activities in federal offshore waters.

Sound Science for Wise Decisions

- Double the nation’s investment in ocean research, launch a new area of ocean exploration, and create the advanced technologies and modern infrastructure needed to support them.
- Implement the national Integrated Ocean Observing System and a national monitoring network.

Education—A Foundation for the Future

- Improve ocean-related education through coordinated and effective formal and informal efforts.

Specific Management Challenges

- Strengthen coastal and watershed management and the links between them.
- Set measurable goals for reducing water pollution, particularly from nonpoint sources, and strengthen incentives, technical assistance, enforcement, and other management tools to achieve those goals.
- Reform fisheries management by separating assessment and allocation, improving the Regional Fishery Management Council system, and exploring the use of dedicated access privileges.
• Accede to the United Nations Convention on the Law of the Sea to remain fully engaged on the international level.

Implementation

• Establish an Ocean Policy Trust Fund, based on unallocated revenues from offshore oil and gas development and new offshore activities, that is dedicated to supporting improved ocean and coastal management at federal and state levels.

6. Examine the entire spectrum of land ownership and ensure that management tools that protect the ecosystem are being used to address all phases of the process.

Land ownership can be understood to occur in phases across a time-continuum. These phases typically include lending, purchase, holding/occupancy, design (or re-design), permitting, construction, inspection, monitoring, and sale to a new owner. Understanding the factors that influence the decision-making of landowners at each phase of their ownership will improve our use of management tools that protect the ecosystem.\(^{42}\)

7. Examine and promote the best incentive programs at the local level.

We recommend studying all available incentive programs to assess which ones will be most effective in concert with regulatory protections to provide the highest level of certainty for the protection of the Puget Sound ecosystem. Consider ecosystem cap and trade markets, offsets, and other innovative approaches. Based on this study, a suite of locally appropriate incentive programs should be adopted by local jurisdictions or offered by non-governmental organizations within each Action Area to support local protection efforts.

8. Require low impact development techniques to be used where appropriate in order to reduce the loss of forest cover and impacts from increases in impervious surfaces.

There is a growing body of knowledge about the potential use of so-called “low impact development” techniques to mitigate for the impacts caused by urbanization, such as the loss of forest cover and the increase in impervious surfaces, as well as to build in more sustainable ways using alternative materials, design techniques and energy systems to increase the efficiency of new buildings. Where those new development and design techniques are well-tested and appropriate for use given landscape conditions, we urge that they be required by state and local agencies. (For more discussion of LID issues and recommendations, please refer to the Water Quality Topic Forum Discussion Paper.)

9. Establish a centralized and transparent approach to managing information, maps, studies, plans and data related to the Puget Sound ecosystem and the Action Agenda.

A centralized approach to information management would maximize transparency, accessibility and the sharing of information to improve our scientific knowledge about the Puget Sound ecosystem.

\(^{42}\)At each phase in this cycle, opportunities arise for activities to occur that either promote or hinder the ecosystem processes, structures and/or functions that exist on or near the property. The factors that influence a landowner’s decision to make use of his or her property at each phase need to be examined, understood and management tools applied (voluntary or regulatory) to promote the protection or restoration of the ecosystem. For example, the banking industry may finance only certain types of construction practices, which are well known and understood, rather than innovative, low impact development projects where the timeframes for approval are uncertain and technologies are less known to them. If incentives are applied to encourage LID in construction practices, but the banking industry isn’t offering financing for those projects, the incentive program may not be effective.
10. Expand the availability of off-site mitigation programs both institutionally and functionally.

Where land or marine use are to be encouraged or where such uses are unavoidable, off-site mitigation may be appropriate if habitat structures or functions are deemed to be of lower relative importance and mitigation is not warranted on-site. Where these circumstances exist, off-site mitigation programs can encourage the funding of habitat or species restoration projects which have been identified and prioritized through such efforts as the creation of ESA recovery plans or other coastal and watershed-scale protection and restoration planning efforts. These programs need to be developed so that mitigation can be analyzed and transferred off-site readily during the permitting process to the locations in the watershed that provide the greatest benefits with respect to restoring ecosystem processes. Currently, barriers exist to fully implementing these types of programs. Such work needs coordination between federal/state/local governments. It will also require changes to many of the key state and local regulations highlighted in Response to Question P1.

11. Educate the public and business community about how to be stewards of their land.

In order to educate the public and business community about how to "do the right thing" or become stewards of their land, the Puget Sound Partnership should work with its partners in the public or private sector to create, if not already available, and promote sets of best practices for suites of land use activities that have the potential to impact ecosystem processes, structures or function. Examples of such activities may include hobby farming, aquaculture, recreational shellfish harvesting, residential development or maintaining residences along shorelines in freshwater or marine areas, and landscaping to enhance stormwater quality both on-site and downstream.

**Preliminary Governance Recommendations**

One of the key findings in Response to Question P1 is that there are simply too many governmental actors in Puget Sound with the authority to regulate human activities that pose threats to the ecosystem. They have acted in an uncoordinated fashion, with varying purposes and results. With each government balancing competing needs and making regulatory decisions, the certainty of outcome decreases and the potential for further ecosystem decline increases.

What the region needs instead is a system of governance where leaders are charged with and capable of ensuring that the Puget Sound ecosystem policy goals are being met. We believe that this requires simplicity. It is important to emphasize that this is not the recommendation for a "super agency" that takes away all responsibility from other state agencies or local governments. Rather, it is a recommendation for a process to create a uniform set of standards that local governments and state agencies will then implement. Local governments will still be able to consider local conditions and circumstances as they develop their implementation measures. This approach will address one major problem many local governments face with the GMA and critical areas regulations.

Under the current statute, scientific disputes over best available science are resolved through protracted litigation before the Growth Management Hearings Boards and the courts. This comes at a significant expense to local governments and diverts scarce resources away from productive measures to protect and improve habitat. It also delays implementation of meaningful regulations as these cases wind their way through the legal process.

The region has tried the uncoordinated, diffuse approach and it has not achieved success organically. Where a single agency or group has been empowered to bring people together to agree on the problem, set goals, and chart a course for correction (such as with salmon recovery planning or growth planning through PSRC) positive outcomes have been shown. The Partnership should actively lead the way. To that end we propose that:

1. The Puget Sound Partnership should convene the region's scientists to reach consensus on the outcomes necessary to protect (or restore) the Sound's ecosystem process, structures and functions described in this discussion paper.
2. Given that the Topic Forum recommends that these outcomes become state regulations, we urge the Partnership to seek rulemaking authority during the next Legislative session. We propose that the Partnership oversee the creation of the protective habitat standard outcomes referenced above and implementation across Puget Sound by local governments.

3. Recognizing that implementing the Action Agenda will likely happen at a local scale, the Partnership should create a nonprofit organization to create new organizations where none exist, or work with collaborative groups, where already in existence, around the Sound to implement the Action Agenda at the local level.

4. Given that the Partnership can play a key role in furthering the federal and international ocean policy reform called for in this paper, the Partnership should lobby Congress to enact the recommendations of the U.S. Commission on Ocean Policy.
## Appendix S1-1: Major process tables for water, sediments, large woody debris, nitrogen, toxins and phosphorous. Adapted from Stanley et al. 2005.

### Freshwater: Water Flow Process - Controls, Important Areas, Stressors and Environmental Responses

<table>
<thead>
<tr>
<th>Component of Process</th>
<th>Major Natural Controls</th>
<th>Important Areas</th>
<th>Stressors</th>
<th>Ecosystem Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery</td>
<td></td>
<td>Recharge areas with higher amounts of precipitation</td>
<td>Change in precipitation</td>
<td>Alters timing, duration and frequency of delivery of water to aquatic ecosystems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recharge areas with higher amounts of precipitation</td>
<td>Loss of forest</td>
<td>Increased frequency of rain-on-snow events. Loss of forest in snow-dominated zone reduces late spring to summer groundwater discharge to streams.</td>
</tr>
<tr>
<td></td>
<td>Timing of snowmelt</td>
<td>Rain-on-snow zones, Snow-dominated zones</td>
<td>Draining and filling of wetlands, Disconnecting stream from floodplain</td>
<td>Increase in water level fluctuations in downstream wetlands and loss of species richness. Increased peak flows downstream which affects stream structure. Disconnecting the stream from its floodplain through channelization or diking increases stream velocity and erosion, bedload transport and reduces structural complexity in streams.</td>
</tr>
<tr>
<td>At the surface</td>
<td></td>
<td>Areas of low gradient Floodplains</td>
<td>Any loss of forest and impervious cover (density)</td>
<td>Reduces deep recharge of larger aquifers. Increases the 2-year peak flow which in turn affects stream structure. Decreases summer baseflows.</td>
</tr>
<tr>
<td>Movement</td>
<td></td>
<td>Recharge areas with high permeability</td>
<td>Loss of forest (&gt;35%), impervious cover (&gt;4%), roads (density)</td>
<td>Reduces recharge of shallow groundwater which can affect early growing season groundwater discharge to wetlands and streams. Increases overland flow and peak flows downstream.</td>
</tr>
<tr>
<td>Below surface</td>
<td></td>
<td>Areas on geologic deposits with low permeability</td>
<td>Any loss of forest and impervious cover (density)</td>
<td>Reduces deep recharge of larger aquifers. Increases the 2-year peak flow which in turn affects stream structure. Decreases summer baseflows.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Areas on geologic deposits with high permeability</td>
<td>Loss of forest on permeable deposits intersecting stream corridors</td>
<td>Reduces recharge and subsequent discharge to water bodies and their associated groundwater systems which may include the hyporheic zone. This in turn impacts stream productivity.</td>
</tr>
<tr>
<td>Return to surface</td>
<td></td>
<td>Slope breaks (steep above, gentle below) intersecting permeable deposits Stratigraphic pinchouts Contact areas between geologic deposits of different permeabilities</td>
<td>Loss of forest on permeable deposits intersecting stream corridors</td>
<td>Reduces recharge and subsequent discharge to water bodies and their associated groundwater systems which may include the hyporheic zone. This in turn impacts stream productivity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entire watershed</td>
<td>Any impervious cover</td>
<td>Alters water budget for watershed.</td>
</tr>
</tbody>
</table>
## Freshwater: Sediment Process - Controls, Important Areas, Stressors and Ecosystem Response

<table>
<thead>
<tr>
<th>Component of Process</th>
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<th>Important Areas</th>
<th>Stressors</th>
<th>Ecosystem Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface erosion</td>
<td>Topography</td>
<td>Steep slopes with erodible soils</td>
<td>Loss of forest on erodible soils (K factor). Roads within 200' of streams (# road crossings) Urbanization</td>
<td>Increases sediment load to streams and wetlands. Increased sediment load raises elevation of wetland and decreases saturation of soils. Water quality, quantity and habitat functions are affected. Increased bedload in streams affects stream structure due to initial steepening of longitudinal profile. Stream adjusts by lowering gradient through bedload transport and deposition which alters stream structure. Increased in-stream erosion can “incise” and disconnect the stream bed from its floodplain and simplify stream structure. Species richness is decreased.</td>
</tr>
<tr>
<td>Mass wasting</td>
<td>Topography</td>
<td>Hazard areas for all slope movement processes including deep seated and shallow, rapid landslides</td>
<td>Roads (density), loss of forest</td>
<td></td>
</tr>
<tr>
<td>In-channel erosion</td>
<td>Transport capacity</td>
<td>Stream corridors</td>
<td>Channelization of streams Urbanization (increases stream discharge)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Riparian vegetation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vegetative cover</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedimentation</td>
<td>Transport capacity</td>
<td>Depressional wetlands Lakes Floodplains and depositional channels</td>
<td>Draining and filling of depressional wetlands Channelizing streams with floodplains Increased streamflow (urbanization) Dams</td>
<td>Depressional wetlands and floodplains remove fine sediment through filtration by vegetation and sedimentation due to slower water velocities. When wetlands and floodplains are filled or floodplains are separated from the streams by channelization, greater quantities of sediment are transported downstream. This negatively affects the structure and function of these downstream wetlands and floodplains. Dams increase sediment storage but change the habitat structure and complexity downstream and upstream of the dam</td>
</tr>
<tr>
<td>Loss</td>
<td>Transport capacity</td>
<td>Decrease or increase in sediment storage</td>
<td>Same causes as for movement</td>
<td>Same response as above</td>
</tr>
</tbody>
</table>
## Appendix S1-1: Major process tables for water, sediments, large woody debris, nitrogen, toxins and phosphorous. Adapted from Stanley et al. 2005.

### Freshwater: Large Woody Debris Process – Controls, Important Areas, Stressors and Ecosystem Response

<table>
<thead>
<tr>
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<th>Major Natural Controls</th>
<th>Important Areas</th>
<th>Stressor</th>
<th>Ecosystem Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streambank erosion and channel stability</td>
<td>Water energy, Riparian vegetation, Erodibility of soils, In-channel wood</td>
<td>Unconfined channels (low gradient floodplains)</td>
<td>Channelization of streams in unconfined reaches</td>
<td>Channelization and armoring reduce erosion and the subsequent fall of trees into streams. Large wood is a principal factor in structuring habitat structure of streams. Large wood moderates scours and channel shifting and facilitates island formation. Large wood also plays an important role in providing habitat structure in estuarine and nearshore areas.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Armoring of streams</td>
<td>Reduces source of large woody debris for streams. Same effect to habitat structure in aquatic systems as above.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Removing riparian vegetation</td>
<td></td>
</tr>
<tr>
<td>Mass wasting</td>
<td>Topography</td>
<td>Hazard areas for shallow, rapid landslides</td>
<td>Remove forest vegetation on high mass wasting hazard areas(^{43})</td>
<td>Reduces source of large woody debris for streams. Small streams recruit majority of wood from upslope areas. Similar effect to habitat structure in aquatic systems as above in erosion.</td>
</tr>
<tr>
<td>Windthrow</td>
<td>Riparian vegetation, Weather patterns</td>
<td>Forest within 100’ from aquatic resources</td>
<td>Removal of vegetation adjacent to stream</td>
<td>Windthrow is an important source of wood in steeper small channels. Reduces source of large woody debris for streams. Similar effect to habitat structure in aquatic systems as above in erosion.</td>
</tr>
<tr>
<td>Storage</td>
<td>Transport capacity of water</td>
<td>Channels with &lt;4% gradient</td>
<td>Channelization of streams in unconfined reaches</td>
<td>Reduces capacity of stream to store wood which reduces supply of large wood to stream systems. Similar effect to habitat structure in aquatic systems as above in erosion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Increased streamflow(^{44})</td>
<td></td>
</tr>
<tr>
<td>Breakage/Decomposition</td>
<td>Biotic interactions</td>
<td>None identified</td>
<td>None identified</td>
<td>None identified</td>
</tr>
</tbody>
</table>

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\(^{43}\) Note that removal of forest vegetation on high hazard mass wasting areas is not legal under State rules
## Appendix S1-1: Major process tables for water, sediments, large woody debris, nitrogen, toxins and phosphorous. Adapted from Stanley et al. 2005.

### Freshwater: Nitrogen Process – Controls, Important Areas, Stressors and Ecosystem Response

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<th>Major Natural Controls</th>
<th>Important Area</th>
<th>Stressor</th>
<th>Ecosystem Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delivery</strong></td>
<td>Nitrogen sources</td>
<td>Additional sources</td>
<td>Agricultural landuse (livestock, dairies, commercial crops)</td>
<td>Excess nitrogen can increase algal blooms in stream systems reducing dissolved oxygen levels and species richness. In nearshore marine systems, excess nitrogen can create conditions suitable for harmful algal blooms.</td>
</tr>
<tr>
<td></td>
<td>Weather patterns</td>
<td></td>
<td>Septic systems (rural residential within 200' of streams)</td>
<td></td>
</tr>
<tr>
<td>Movement</td>
<td>Biotic uptake and decomposition</td>
<td>Headwater streams</td>
<td>Channelization of headwater streams (&lt;10m)</td>
<td>Uptake reduced by deepening of stream channel and removal of riparian vegetation. Base of stream food chain affected including photosynthetic and heterotrophic biota (i.e. fungi and bacteria) and invertebrates. As a result, biologic productivity of headwater streams is reduced.</td>
</tr>
<tr>
<td>Nitrification</td>
<td>Hydrologic regime</td>
<td>Depressional wetlands (excluding bogs and fens)</td>
<td>Draining or filling of depressional wetlands</td>
<td>More nitrogen is transported downgradient.</td>
</tr>
<tr>
<td>Adsorption</td>
<td>Hydrologic regime</td>
<td>Headwater streams</td>
<td>Channelization of headwater streams</td>
<td>Same effects as above.</td>
</tr>
<tr>
<td><strong>Loss</strong></td>
<td>Denitrification</td>
<td>Depressional wetlands</td>
<td>Draining or filling of depressional wetlands</td>
<td>More nitrogen is transported downgradient (in both surface water and groundwater).</td>
</tr>
<tr>
<td></td>
<td>Hydrologic regime</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surficial geology</td>
<td>Riparian areas with consistent supply of shallow groundwater in permeable deposits</td>
<td>Interception of shallow groundwater flow before it discharges in riparian and floodplain areas</td>
<td>Nitrogen is transported downstream to estuaries and nearshore marine environments. See “Delivery” for additional response.</td>
</tr>
<tr>
<td></td>
<td>Groundwater flow paths</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reactive sites</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix S1-1: Major process tables for water, sediments, large woody debris, nitrogen, toxins and phosphorous. Adapted from Stanley et al. 2005.

### Freshwater: Toxins and Phosphorous Processes – Controls, Important Areas, Stressors and Ecosystem Response

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<th>Major Natural Controls</th>
<th>Important Area</th>
<th>Stressor</th>
<th>Ecosystem Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phosphorus sources</strong></td>
<td>Climate patterns</td>
<td>Areas contributing additional sources</td>
<td>Agricultural and urban land use (application of fertilizer, livestock dairies)</td>
<td>Phosphorous is a limiting nutrient in freshwater ecosystems. Additional sources can exceed the capacity of soils to adsorb phosphorous which results in downgradient transport. In aquatic systems, especially lakes, excess phosphorous results in eutrophication and reduction in species richness. Though not a limiting nutrient in marine systems, phosphorous plays a role in promoting harmful algal blooms.</td>
</tr>
<tr>
<td><strong>Toxin sources</strong></td>
<td>Surficial geology</td>
<td>Areas contributing additional sources of toxins</td>
<td>Agricultural and urban land use (application of pesticides, herbicides, and other chemicals)</td>
<td></td>
</tr>
<tr>
<td><strong>Surface erosion</strong></td>
<td>Soil type</td>
<td>Most soils derived by glacial deposits</td>
<td>Removal of vegetation and grading for new development</td>
<td>Naturally occurring phosphorous, adsorbed to sediment, is transported by overland flow to downgradient aquatic systems.</td>
</tr>
<tr>
<td><strong>Biotic uptake and decomposition</strong></td>
<td>Biotic cover &amp; composition</td>
<td>See ecosystem response</td>
<td>See ecosystem response</td>
<td>Because this is an annual process of uptake in the growing season and release in the fall these areas (i.e. emergent &amp; decidous vegetation) are not significant sinks for phosphorous and toxins in urban areas.</td>
</tr>
<tr>
<td><strong>Adsorption (P)</strong></td>
<td>Soil characteristics</td>
<td>Areas with organic and clay soils</td>
<td>Draining or filling of depressional wetlands with mineral soils</td>
<td>Depressional wetlands are effective sinks for phosphorous. Draining and filling transports phosphorous downgradient to other aquatic systems.</td>
</tr>
<tr>
<td><strong>Adsorption (T)</strong></td>
<td>Soil cation exchange capacity</td>
<td>Areas with organic and clay soils</td>
<td>Draining or filling of wetlands with organic and clay soils</td>
<td>Depressional wetlands are effective sinks for toxins. Draining and filling transports toxins downgradient to other aquatic systems.</td>
</tr>
<tr>
<td><strong>Sedimentation</strong></td>
<td>Water transport capacity (velocity)</td>
<td>Reduced storage of phosphorous &amp; toxins</td>
<td>See Sedimentation Process</td>
<td>See Sedimentation Process</td>
</tr>
</tbody>
</table>
Appendix S1-1: Major process tables for water, sediments, large woody debris, nitrogen, toxins and phosphorous. Adapted from Stanley et al. 2005.

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</tr>
</thead>
<tbody>
<tr>
<td>Delivery</td>
<td>Fecal inputs</td>
<td>Wildlife</td>
<td></td>
<td>Failed septic systems Discharge of untreated human and animal waste</td>
</tr>
<tr>
<td>Movement</td>
<td>Overland flow</td>
<td>Precipitation patterns Soils</td>
<td></td>
<td>Ditching &amp; draining of saturated areas, removal of forest cover, soil disturbance, and impervious cover</td>
</tr>
<tr>
<td>Movement</td>
<td>Transport</td>
<td>Topography Surficial geology Soils</td>
<td>Urban, rural and agricultural areas</td>
<td>Channelization of streams</td>
</tr>
<tr>
<td>Transport</td>
<td>Surface flows</td>
<td>Topography Surficial geology</td>
<td></td>
<td>Impervious cover Ditching in areas of low permeability</td>
</tr>
<tr>
<td>Movement</td>
<td>Subsurface flows &amp; Recharge</td>
<td>Topography Surficial geology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement</td>
<td>Adsorption</td>
<td>Mineral and organic soils Surficial water velocity</td>
<td>Wetlands and floodplains</td>
<td>Ditching, draining or filling depression wetlands with mineral and organic soils</td>
</tr>
<tr>
<td>Movement</td>
<td>Sedimentation</td>
<td>UV radiation. Starvation and predation</td>
<td>Depressional wetlands and floodplains</td>
<td>Draining or filling of depressional wetlands with mineral and/or organic soils</td>
</tr>
<tr>
<td>Loss</td>
<td>Death</td>
<td>Depressional wetlands and floodplains</td>
<td></td>
<td>Increased movement and transport of pathogens downgradient to freshwater and marine ecosystems.</td>
</tr>
</tbody>
</table>
Appendix S1-2: A preliminary overview of Action Area conditions and threats. Table refinements should be made based on input from the Topic Forum on April 28th and from the “Action Area Profiles” currently being developed.

<table>
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<th>Action Area</th>
<th>Land Uses</th>
<th>Watershed and Terrestrial Habitats</th>
<th>Dominant Marine and Estuarine Habitats</th>
<th>Action Area-Specific Major Threats1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strait of Juan de Fuca</td>
<td>Headwater areas largely protected in national park (Olympic), except for Hoko and Pysht areas. Outside of protected areas, most mid- to low-elevation areas are in forest and forestry uses. Three moderate-sized UGAs (Port Angeles, Sequim and Port Townsend) are present, located away or mostly away from major river headwaters, corridors and river mouths. Two UGAs (Port Angeles and Port Townsend) have significant development along marine nearshore areas. Otherwise, low elevation areas are dominated by mostly rural residential uses.</td>
<td>Terrestrial – higher elevations contain mixed conifer forests and hemlock and silver fir, lower elevation forests contain hemlock and fir with woodlands and shrubs lands in riparian areas. Freshwater – rivers include the Dungeness, Elwha, Lyre, Pysht, East and West Twin, and Hoko, with many smaller river and stream systems. Lakes Crescent and Sutherland are the largest natural lakes in the area.</td>
<td>Large amounts of rocky reef and kelp habitats (particularly towards western end); sand and gravel beaches and flats, large sand spits at Port Angeles (although affected by lack of sediment from Elwha) and Sequim (Dungeness River mouth), large embayments (Discovery Bay, Sequim Bay), estuaries at mouths of major rivers and many small creeks, moderate human shoreline uses at Neah Bay, Clallam Bay, Port Angeles, and Sequim.</td>
<td>Barriers, especially on the Elwha River, but also on many small stream and in floodplains where old culverts remain, affect fish passage and free flow of materials such as water, sediment and LWD. Forest cover loss and conversion to development is localized (in and near UGAs) and is localized conversion of natural stream systems to artificial ditches, floodplain development. Large woody debris (LWD) and forest type is affected by extensive past logging as well as more localized floodplain and riparian development. Localized riparian and floodplain development also create impacts for floodplains and riparian conditions. Nearshore areas are threatened by increased residential development, fecal coliform and nutrient additions to bays (especially Dungeness Bay), shoreline armoring, fish and shellfish harvest, commercial development along ports.</td>
</tr>
</tbody>
</table>
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</tr>
</thead>
<tbody>
<tr>
<td>Hood Canal</td>
<td>Western headwater and mid-reach areas are steep and largely contained in</td>
<td>Terrestrial – higher elevations contain mixed conifer forests and hemlock and silver fir;</td>
<td>Dominated by sand and gravel beaches and flats, more sand beaches in Hood Canal than other</td>
<td>Loss of forest cover, activities that increase impervious surfaces, shoreline modifications, habitat fragmentation; blockage of salmon access to high elevation river habitats.</td>
</tr>
<tr>
<td></td>
<td>park (Olympic) and Forest Service lands with scattered rural development.</td>
<td>lower elevation forests contain hemlock and fir with woodlands and shrub lands in riparian</td>
<td>Action Areas, embayments (Dabob and Quilcene bays), estuaries and wetlands at mouths of major</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Southern and eastern headwater areas are relatively flat and dominated by</td>
<td>areas. Freshwater – major rivers include the Skokomish, Hamma Hamma, Duckabush, Dosewallips,</td>
<td>rivers and many small creeks. Heavier human shoreline uses at Port Townsend and Belfair.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>second and third growth forest and related timber harvesting activities</td>
<td>Quilcene and Tahuya. Lake Cushman – an artificial reservoir - is the largest lake in the</td>
<td>Moderate uses at other small towns bordering the canal, like Seabeck and Brinnon.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and extensive rural development. Low elevation areas and marine shorelines</td>
<td>Action Area.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>mostly in rural development w/ variable degrees of development and</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>alteration, the most intense of which are along the northeastern shores.</td>
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</tr>
</tbody>
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</tr>
</thead>
<tbody>
<tr>
<td>San Juan/Whatcom</td>
<td>San Juan – rural lands dominate, some forestry, agriculture, conservancy lands, and a few small towns (UGAs).</td>
<td>San Juan – terrestrial habitats dominated by fir-hemlock-cedar forest, also significant patches of madrone forest, grasslands, scrub-shrub, and rock outcrops. Freshwater habitats are primarily small, intermittent streams and lakes. Whatcom - terrestrial – higher elevations have glaciers, rock outcrops, and hemlock and mixed conifer forests. Hemlock and Douglas fir forests line higher elevation streams, becoming riparian woodlands and shrub lands and crop lands along the river in the lowlands. Douglas fir, hemlock, and red cedar forests dominate upland areas in the Puget Sound lowlands. Freshwater – the Nooksack River is the major riverine system. Major lakes are Samish and Whatcom.</td>
<td>San Juan - dominated by rock cliffs, rocky reefs and kelp habitats on islands, interspersed gravel beaches, numerous small embayments within the islands, moderate human shoreline uses within major towns on larger islands (San Juan, Orcas, Lopez, Shaw), marinas on many islands. Whatcom - dominated by sand and gravel beaches and flats, some mudflats and rock cliffs, estuaries and wetlands at mouth of Nooksack River and small creeks, heavy human shoreline uses at Bellingham and Blaine.</td>
<td>Marine shoreline modifications, activities that increase impervious surfaces – transportation infrastructure, land conversion, loss of vegetation, upland/shoreline habitat connectivity.</td>
</tr>
</tbody>
</table>
Appendix S1-2: A preliminary overview of Action Area conditions and threats. Table refinements should be made based on input from the Topic Forum on April 28th and from the “Action Area Profiles” currently being developed.

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</tr>
</thead>
<tbody>
<tr>
<td>Whidbey Basin</td>
<td>Headwater areas largely protected in park (North Cascade) and wilderness lands. Mid-elevations mostly in forestry, protected uses, scattered small UGAs and rural residential development. In low elevation and along marine shorelines, UGAs ranging from small to large, mostly situated near the mouths of the Snohomish and Skagit Rivers. Extensive agriculture in lower and mid-valley floodplains of all major rivers.</td>
<td>Terrestrial – higher elevations have glaciers and hemlock and mixed conifer forests. Hemlock and Douglas fir forests line higher elevation streams, becoming riparian woodlands and shrub lands along larger rivers in the lowlands. Douglas fir, hemlock, and red cedar forests dominate upland areas in the Puget Sound lowlands. Freshwater – major river systems include the Skagit, Stillaguamish, and Snohomish. Largest lakes are reservoirs, include Baker and Ross.</td>
<td>Large freshwater influence from Skagit River, large estuary and wetland areas in Skagit, Padilla, and Everett bays, eelgrass meadows in sand and mud flat bays, large areas of sand and gravel beaches and flats. Whidbey and Camano islands provide some shoreline protection, some rocky/sandy cliffs, estuaries at mouths of major rivers and many small creeks. Heavy human shoreline uses in Everett, moderate shoreline uses along island shorelines.</td>
<td>Activities that increase impervious surfaces - transportation infrastructure, land conversion, agricultural practices, forest loss predominately along marine shorelines, and in low elevation areas. Mid elevation areas still recovering from extensive historic logging impacts. Dams on the Skagit and Baker Rivers; conversion of agricultural lands to non-agricultural uses; invasive plant species.</td>
</tr>
<tr>
<td>North Central Puget Sound</td>
<td>Mix of small to medium sized UGAs w/ extensive scattered rural residential development all in low elevation and low topographic relief settings. Scattered small agriculture and forestry.</td>
<td>Terrestrial- Douglas fir, hemlock, and red cedar forests dominate upland areas. Freshwater – many small streams and lakes such as Chico Creek and Wildcat Lake.</td>
<td>Dominated by sand and gravel beaches and flats, sometimes backed by feeder bluffs. Estuaries at mouths of many small creeks, heavy shoreline uses at Bremerton, moderate uses at Poulso, Port Orchard, Eagle Harbor, Keyport, Gig Harbor.</td>
<td>Marine (and freshwater) shoreline modification and vegetation removal, habitat fragmentation.</td>
</tr>
</tbody>
</table>
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</tr>
</thead>
<tbody>
<tr>
<td>South Central Puget Sound</td>
<td>Major and extensive UGAs in lower elevations and along Sound shorelines and estuaries. Medium to small UGAs scattered in surrounding low to mid elevation areas. Extensive rural and development outside UGAs and localized agriculture along undeveloped low elevation floodplains. Mid to high elevation forests in protected or commercial forestry activities.</td>
<td>Terrestrial - Douglas fir, hemlock, and red cedar forests in upland areas, riparian forests and woodlands along rivers and streams. Many forest have high proportion of deciduous trees relative to predevelopment condition. Freshwater - major river systems are the Green/Duwamish, Puyallup/White, Cedar and Sammamish; large lakes are Washington and Sammamish (WA’s second and sixth largest lakes, respectively); many smaller lakes and streams. The Green/Duwamish River and the Lake Washington systems have undergone dramatic “re-plumbing.” The Duwamish has been straightened and dredged.</td>
<td>Dominated by sand and gravel beaches and flats, sometimes backed by feeder bluffs. Small, typically developed estuaries at mouths of major rivers (Duwamish, Puyallup), smaller estuaries at many small creeks. Significant portions of shoreline armored by railroad, heavy shoreline uses in many areas focused around Seattle, Tacoma, moderate uses throughout eastern side, less intensive shoreline uses on Vashon and Maury Islands.</td>
<td>Activities that increase impervious surfaces – transportation infrastructure, land conversion; dams on the Cedar, Green and White Rivers; blockage of salmon access to high elevation river habitats; armoring for railroad has reduced sediment inputs.</td>
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</tbody>
</table>

1 See Table S1-1 for an overview of threats common within the Puget Sound watershed. Those of particular concern are noted for each Action Area. 
Sources: Ruckelshaus and McClure 2007; PSAT 2007a; PSAT 2007b; San Juan County Marine Stewardship Area Plan; County comprehensive plans; Puget Sound Chinook Salmon Recovery Plan; Department of Natural Resources Shorezone database.
Appendix S1-3: The East Jefferson County Case Study

Performing Ecosystem Rapid Assessments for the Puget Sound Action Areas

July 3, 2008

Introduction

Much has been written about the fact that Puget Sound and many of its species are in trouble. In enacting the Puget Sound Partnership legislation in 2007, the State Legislature announced that we can no longer wait to solve the problems contributing to the Sound’s decline. In launching the Action Agenda project to guide our efforts, the Partnership has set a course to reach a healthy Puget Sound by 2020. NOAA scientists and others are performing a sound-wide risk assessment that should provide the scientific basis for further actions. This work is underway now and should be complete by 2010.

In the meantime, the Land Use/Habitat Protection and Restoration Topic Team Forum (“Forum”) was charged with answering the question, “What is the status of the habitat in Puget Sound?” The preliminary answer is found in the Forum’s Summary Paper. A critical finding in the Summary Paper is that there are significant gaps in our understanding about both the status of stressors or threats to habitat, and about the opportunities that may exist to preserve or restore important parts of the Puget Sound as an integrated landscape and seascape that functions together as an ecosystem.

Understanding the urgency to move forward now, the Topic Forum recommends that the Partnership pursue a rapid, watershed-scale “ecosystem assessment” within each Action Area. The purpose of the rapid assessment is to provide a coarse-scale to fine-scale understanding of the “habitat” threats/stressors and opportunities that exist in each Action Area.

The Forum believes that this information will serve two purposes. First, it will help the articulation of a set of “habitat outcomes” that describe a properly functioning ecosystem where ecosystem processes, structures and functions are intact. Second, once completed, the rapid assessment will provide early information to the Puget Sound Partnership and local leaders about the status of habitat across the Sound, and where opportunities exist in watersheds to make more strategic decisions about where to begin to provide enhanced protection and/or restoration activities throughout Puget Sound, until further scientific studies deliver more information to guide our work.

Before the Forum determined that it should make such a recommendation, it was felt that a rapid assessment should be attempted within a portion of Puget Sound in order to understand whether the recommendation would be feasible, and to better understand the challenges and benefits of such an approach. The Forum recognizes that there are benefits and drawbacks from a “rapid assessment” approach. The benefit of such assessments is that they can yield quicker results, are less detailed and quantitative, convene experts across disciplines (e.g., science, planning, law) and result in a faster resolution of information conflicts or gaps and synthesis of information to achieve recommendations. The drawback of such assessments is that there may be an increased risk of errors based on faulty information or a lack of local consensus on recommendations if local input is not considered. As such, the Forum believes that a strong adaptive management, monitoring and scientific research program should be used to support actions taken as a result of rapid assessments so that course corrections can be taken if errors are made. In addition, the Forum recommends that a public process that convenes and includes input from local stakeholders should accompany each rapid assessment.

The Importance of Planning at an Ecosystem or Watershed Scale

Much of the recent research concludes that the protection, management and regulatory activities could be more successful if they incorporated an understanding of “ecosystem” or “watershed processes,” terms which mean that we should consider the natural environment in a more holistic, connected fashion. Traditionally, most planning has focused on the site scale without an understanding of watershed processes. Scientific studies have shown that watershed processes interact with landscape features, climate, and each other to produce the structure and functions of aquatic ecosystems that society is interested in protecting. As noted in Land Use/Habitat Protection and Restoration Topic Forum Paper, the tools that exist today to manage land use and human impacts to aquatic and terrestrial systems in Puget Sound are fragmented. One result of this fragmentation is that our tools are neither achieving a unified watershed approach nor ensuring protection of the habitat and natural systems that matter most for long-term health of Puget Sound.

Ecosystem-based characterizations through rapid assessments can provide decision-makers with specific information in the short term about where those places are (or should be, if already lost or altered), and what challenges or opportunities exist.

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In this paper, the term “ecosystem-based” or “watershed-based” characterizations is meant to refer to assessments of both upland aquatic and terrestrial habitats coupled with nearshore, coastal and deep subtidal habitats.
exist in making their protection (and restoration) a top priority. The Topic Forum Team believes that understanding habitat processes, structures and functions will improve land use planning and management, and will help identify the best areas for restoration and protection and the best locations for offsite mitigation. We also believe that the success rate of mitigation and restoration efforts will improve using a watershed approach.

A unified and coordinated approach to the characterization and management of watersheds has been recommended by the Washington State Department of Ecology\textsuperscript{46}. Such an approach requires the equal participation and endorsement by key state and federal agencies in conjunction with local planners and citizens at the planning level. Participants agree to a detailed management framework, based on the watershed characterization, which is then incorporated into a local adopted plan. The plan spans areas regulated under both the GMA and the SMA and can include multiple jurisdictions within a watershed. The detailed adopted plan streamlines the permitting process by identifying the best areas for mitigation (protection and restoration), the mechanisms for accomplishing such mitigation and what the monitoring requirements would be. Overall, this approach is predicted to reduce the time and cost typically associated with site by site review and enforcement, and provide a greater degree of certainty and predictability for local governments in regulating sensitive habitats at the permit level.

Watershed planning has been ongoing in many local areas across Puget Sound for years. However, watershed planning linked with nearshore, coastal and deepwater marine systems has only recently been attempted in very limited areas. Some efforts are organized around water supply, and others focused on salmon recovery planning. The Habitat Topic Forum believes that existing watershed plans (including salmon recovery or other species recovery plans) linked with emerging assessments and plans that include nearshore ecosystems should be used in performing rapid assessments, where those plans have characterized a watershed from a broader ecosystem perspective, to avoid duplicating prior efforts.

The Jefferson County Case Study – Purpose, Scope and Limits

The purpose of the case study was to understand the feasibility and challenges of performing a rapid ecosystem assessment in the Action Areas of Puget Sound. The Forum examined a number of potential areas and ultimately chose to focus on eastern Jefferson County because it presented an area where prior work had been done that could be used in a very short period of time.

Based on the time constraints of the development of the Action Agenda and the Topic Forum Papers, the Habitat Topic Forum limited the case study in several ways. First, the Habitat Topic Forum used only existing information which was available from prior scientific studies or research and public sources, such as information readily available from public agency websites. Second, the Forum did not consult with or seek the assistance of Jefferson County, the cities within the jurisdiction, or any organized local group prior to performing the assessment. Third, the Habitat Topic Forum assessed the status of ecosystem processes for the eastern portion of Jefferson County, rather than a single watershed. Finally, given time constraints, the Forum examined only one of several ecosystem processes, and its related structures and functions – water flow – and did not assess other important ecosystem processes which would ordinarily be included.

The Habitat Topic Forum recognizes that in an ideal setting, a rapid assessment would include participation and information from the local community being assessed, and should include an analysis of all ecosystem processes, structures and functions. It may also make more sense, depending on the location, to change the geographic scale (county, city, watershed, sub-basin) of rapid assessments to suit the local conditions or circumstances within each Action Area.

The Rapid Assessment Methodology

In terms of examining the watersheds in Puget Sound, the group decided to examine eastern Jefferson County according to the watersheds existing within the political boundary, and characterize each of them. However, based on time constraints, the Topic Forum Team was only able to consider a single process – water flow—rather than all ecosystem processes, which would have provided a more complete view of the area and better management recommendations. However, as noted above, the goal of our work was as much to determine the methodology for doing rapid assessments that would result in a watershed characterization, as it was to reach conclusions about the status of the watersheds in Jefferson County itself. Assessments of nearshore conditions that are linked partially to watershed conditions in Jefferson County provided the first attempt in the State outside of ESA or forestry plans to comprehensively assess “ecosystem” conditions, and to prioritize actions and land use recommendations based on these assessments.

\textsuperscript{46}Developing a Watershed Characterization & Analysis Approach for Meeting Multiple Mandates in Washington State; prepared by the Washington State Department of Ecology, et. al., (Feb. 23, 2006).
This “learn by doing” approach brought together a diverse team of scientists, planners, regulators, attorneys, architects and natural resource consultants to quickly synthesize information that already existed and identify what other information might be helpful. We learned from each other about what was important ecologically in terrestrial and aquatic areas. We also examined the current GMA land use framework within these ecological systems exist and how protection of the land and water was, or could be, impacted in the future by land use policy decisions. Where possible, we discussed what incentive tools might be used to encourage local landowners to protect important ecological systems.

Characterizing an ecosystem begins at the broadest scale over which processes operate in the area being analyzed. From a land use management standpoint, this scale can be viewed on a countywide scale or other, large management unit. Next, the characterization provides an assessment of processes at the sub-basin or mid scale. From a land use management standpoint, the sub-basin scale allows for identification and prioritization of the best areas for protection, restoration and development. The mid or sub-basin scale assessment allows planners to evaluate and plan for the best patterns of development and mitigation at the fine or site scale. The fine scale is where structure and function operate and serve the essential life stages of fish or animals.

At each scale, the Topic Forum Team determined that it was important to examine a number of considerations:

- A basic Inventory of Land Type by GMA class
- Areas most sensitive to changes from land use
- Population – existing and future expected growth
- Water quality and water flow processes
- Habitat condition and Biodiversity (Biodiversity maps)
- Shoreline conditions and priority actions (Diefenderfer et al.)
- Identified priority areas for protection and restoration (Stanley, et al.)
- Planned or Potential Future Land/Shore development patterns (Jefferson County Future Land Use Maps)
- An overall synthesis of all of this information to develop a cohesive characterization of the study area that includes both terrestrial, freshwater and saltwater components.

The Watershed Assessment (upland and freshwater areas)

In the particular case of eastern Jefferson County, a watershed characterization had been previously performed which identified priority areas for restoration and protection, shown in a series of maps. See, Draft Watershed Characterization of Jefferson County, May 16, 2007, Version 3, Wash. State Dept. of Ecology, Shorelands and Environmental Assistance Program. This work was highly valuable in completing our work in such a short time frame. The approach and scientific methodology used in that work is set forth in selected part, below:

1.2 Approach

Characterizing processes within the watersheds of the study area is central to developing a successful watershed based mitigation plan. An adequate characterization will provide local jurisdictions with information on the best areas for mitigation, protection of watershed processes, and development.

For example, this watershed characterization and analysis will help us identify areas that are important or key for maintaining watershed processes and how much these areas have been altered (Figures 3 and 4). A matrix (Figure 5) is then applied that evaluates the degree of importance and alteration for each basin, which in turn can produce a final map showing priorities for protection and restoration (Figure 6).

Our management and regulation of these aquatic ecosystems have typically concentrated on the biological, physical, and chemical character of the individual lake, wetland, stream reach or estuary, and not on the larger watershed that controls these characteristics.

However, the central assumption to this characterization approach is that the health of habitat and associated aquatic resources is dependent upon intact upgradient (upstream/upslope) watershed processes. Research has demonstrated that we must consider the watershed processes originating in terrestrial areas if we are to protect and restore our lakes, rivers, wetlands, and estuaries, (National Research Council 2001, Dale et al. 2000, Bedford and Preston 1988, Roni et al. 2002, Poiani et al. 1996, Gersib 2001, Gove et al. 2001).

Watershed Processes: In this document, watershed processes refers to the dynamic physical and chemical interactions that form and maintain the landscape at the geographic scales of watersheds to basins (hundreds to thousands of square miles). These processes include the movement of water, sediment, nutrients, pathogens, toxins, and wood as they enter into, pass through, and eventually leave the watershed. For example, flooding by streams can create off-channel habitat that is important for fish. Much of the research concludes that protection, management, and regulatory activities could be more successful if they incorporated an understanding of watershed processes.

2.0 Methods

For this project, the tools proposed for application are: 1) DOE publication #05-06-027, “Protecting Aquatic Ecosystems: Volume 1, A Guide for Puget Sound Planners to Understand Watershed Processes.” This document provides guidance on how to conduct a coarse scale characterization for multiple processes; 2) “Protecting Aquatic Ecosystems: Volume 2 Models for Understanding Watershed Processes.” This is a draft document that presents numeric models for implementing the guidance presented in Volume 1 and is attached to this document in Appendix B. These tools represent one possible way to conduct a characterization and should not be considered the only method recommended by the Land Use and Habitat Team.

The hydrologic process was characterized for Jefferson County. The qualitative description for analyzing watershed processes is presented in appendices B through G of publication 05-06-027 (Volume 1). These appendices provide a tabular description of how to analyze the individual components of those processes. Volume 2 provides examples of numeric models that can be constructed to identify the geographic locations in a watershed that are key to the delivery, movement and loss of water (Tables B-1 and B-3 in Appendix B). The equations in these models use the environmental characteristics described in the tables as variables in equations that establish importance.

In general, variables are assigned maximum values of 1, 2 and 3; representing respectively, low, medium and high “importance” of a characteristic or “alteration” of a characteristic. The models are constructed so that higher total scores represent sub-basins or basins of greater importance for supporting a process in a watershed, or one with a higher degree of alteration to that process. The scoring is normalized to conditions specific in a watershed or basin. Thus the models provide a comparison of the relative level of importance and alteration of process components (see Step 3 and 4 of DOE publication 05-06-027). The scores do not represent a specific rate (e.g. rate of removal of sediment or nitrogen) or specific level of alteration of a process that can be compared to scores outside of an analysis area. We do not have enough information at this time to calibrate models to conditions throughout the state and establish relative importance of processes and alterations among different watersheds.

Appendix B of [the draft Watershed Characterization] presents the scoring methods in detail and a series of maps that display the results of the numeric models applied to the freshwater watersheds of Jefferson County.

3.0 Hydrogeologic Units

This characterization uses a hydrogeologic classification approach based on the “hydrologic-landscapes” work of Winter (2001) and the hydrogeologic work of Bedford (1999 & 1988). This landscape approach considers regional climate, surficial geology, topography, groundwater and surface flow patterns and morphology in relationship to aquatic resources. Jefferson County has already established hydrologic units for the County based previous watershed planning efforts (i.e. 2514). This characterization study modifies these hydrologic units in order to maintain the relationship between processes and the aquatic ecosystems that they influence (i.e. process, structure and function relationship). Whereas the County hydrologic units are based primarily on the surface water boundaries of major stream and river systems, this analysis groups units based on precipitation type, subsurface and surface water flow patterns, and geology and landform.

These units were also divided so that watersheds with significantly different levels/patterns of precipitation and geomorphology and were not compared to one another in the scoring. For example, because the watersheds within the Large River Unit (i.e. Big Quilcene) unit have higher precipitation levels they will score higher than the Small River unit if analyzed together. The Small River unit, however, support important aquatic ecosystems and should be characterized separately from the Large River unit so that characterization scores are not artificially suppressed by the scores for the higher precipitation levels in the watersheds of Large Rivers.

The Shoreline Assessment

In addition to the Jefferson County Watershed Characterization, the Forum Team also used the existing work of Diefenderfer, H.L., K.L. Sobocinski, R.M. Thom, C.W. May, S.L. Southard, A.B. Borde, J. Vavrinec, and N.K. Sather, Multi-
scale analysis of restoration priorities for marine shoreline planning. Environmental Management. Submitted December, 2007. (In Revision). The study is anticipated to be published soon. However, the following represents a short summary of the shoreline assessment project's methodology.

The area that was characterized by the study included the East Jefferson County shorelines. (West Jefferson County was not included because it consists of Federal and Tribal lands not subject to the County’s jurisdiction under the Shoreline Management Act). The shorelines that were included can generally be characterized as partially exposed, semi-protected or protected according to Dethier (1990).

These marine shorelines were grouped into two Water Resource Inventory Areas (WRIs), with similar geomorphological conditions: WRIA 17, which encompasses most of East Jefferson County, including shorelines on the Strait of Juan de Fuca, Admiralty Inlet, and North Hood Canal; and a small portion of WRIA 16, with shorelines on north Hood Canal. WRIA 17 is characterized by large and small bays with streams that are not associated with the Olympic Mountains. WRIA 16 is characterized by two major rivers, the Dosewallips and Duckabush, and smaller lowland streams. The study grouped the shorelines into two groups because of the difference in connection (or absence of a connection) to upland perennial streams or rivers.

The shoreline study documented an approach to determining the conservation or restoration strategy most likely to succeed based on current conditions at local and landscape scales. Their analysis was structured by an ecosystem conceptual model, which identified anthropogenic impacts, or stressors, as well as targeted ecosystem functions, and considered relevant spatial scales and hydrologic context. They used existing high quality, quantitative GIS data from multiple sources (state, tribal, and local county).

A scoring system, weighted by geomorphic class, was applied to available spatial data on stressors and functions at three scales: shore zone unit, drift cell reach, and watershed. The scoring system was simple, requiring minimal interpretation to achieve the maximum consistency in scoring result, while at the same time avoiding or double counting. An important part of the scoring system is that it was guided by quantitative data. Critical parameter values were derived from literature or percentile distributions of data.

Using the output from the watershed assessment to characterize such factors as sediment delivery and nutrient input, the nearshore assessment was able to score the relative “threat” of a damaged watershed to the receiving nearshore landscape (e.g., drift cell). Next, appropriate conservation and restoration strategies were paired with sites based on the likelihood of producing resilience to disturbance given the condition of local and landscape scale ecosystem structures and processes. This decision framework augments historical conditions and change analysis, as well as ecosystem valuation, providing a science-based planning tool in GIS.  

The Combined Ecosystem Assessment for East Jefferson County

To complete its analysis of the entire ecosystem in East Jefferson County, the Habitat Forum Team assembled the information from the prior watershed and marine shoreline assessments, along with the Jefferson County land use planning policies, land use designations and future land use map, surface water management plan, and proposed critical areas regulations and staff report. The team analyzed the County according to the existing GMA land types, beginning with urban growth areas (“UGA”) or urbanized lands, if not formal UGAs, rural lands, and finally, natural resource lands (forest, mineral and agricultural). The team documented a short summary of the combined analysis in a table, considering General Habitat Status and Stressors on Water Processes, projected population growth, the status of upland/terrestrial habitat, the status of marine and shoreline areas, the status of freshwater systems and the status of biodiversity within each land type. After each land type was characterized, a synthesis of the status of the area according to hydrologic processes, structures and function was discussed, along with the stressors or threats currently or potentially faced by each land type given current adopted plans, zoning, or other land use controls. Finally, a synthesized set of recommendations was included for each land type, focusing on protecting areas at risk from existing or future stressors and restoring areas important for hydrologic processes.

The summary of the team’s analysis is presented below, along with recommendations for reach land use type for preserving and restoring ecosystems functions within each area.

The Rapid Assessment Findings

Jefferson County is a rural county with a small population relative to other areas in Puget Sound. However, it is projected to nearly double in size by 2025, which has the potential to concentrate new population within a relatively small, habitable area of the County, due to steep, publicly-owned or lands that are not otherwise available for development. The County’s current urban development is concentrated in areas where it has the least potential for disrupting hydrologic processes.
Large scale impacts to processes are low for most rural areas except in the Quimper peninsula. However, the greatest opportunity for restoration is in lands adjacent or upstream of urban development in Port Townsend and these areas may be subject to further degradation if future development pressure from the urban areas is not properly planned and located. The other major threat or stressor in this County is within rural lands that are largely forested and have a high potential for future clearing and habitat disruption, whether for forestry or for long-term conversion of the land to another, more intensive use. The marine shorelines in the County are in fairly good condition, considering existing development impacts, and score on average as “moderate” in terms of habitat health. The shorelines have few areas that are heavily damaged and modified. The primary threats to marine shorelines are the potential loss of nearshore riparian areas due to development; continued armoring; effects from upland watershed changes (agriculture – nutrients) and over-water structures. The Port Townsend shoreline is heavily impacted in terms of the feeder bluffs and sediment process.

Areas within Jefferson County were characterized for the health of hydrologic processes by the Department of Ecology. Their findings revealed:

The Olympic Mountains and the adjoining lowlands have the largest relative area of “high” importance to watershed processes. This is due to the presence of higher precipitation (rain-on-snow, snow dominated zones), and areas important to surface and groundwater processes throughout this area (surface storage and infiltration, percolation and recharge). The Little Quilcene watershed was of lower overall importance due to a higher degree of impermeable deposits and lower relative rainfall.

The headwaters for the Chimacum drift plain score as a “high importance” as do watershed areas draining to Tarboo and Quilcene Bays. The high importance of the Chimacum area is primarily due to the presence of wetlands and floodplains and relatively large areas of permeable deposits and moderate rainfall levels. The Tarboo Creek, Thorndyke Creek, Toandos Peninsula (west side), and Donovan Creek watersheds score high due to the presence of important areas for groundwater processes (infiltration, percolation and recharge). Other areas of lower importance were primarily the small nearshore marine watersheds that are in areas of low rainfall and fewer areas for storing surface water (i.e. wetlands and streams). (Figure 1)

Large areas of the County are suitable for protection due to large tracks of forest (of all age classes) and low level of alteration including limited coverage by impermeable surfaces and roads. Key areas for restoration include the Chimacum Valley, Leland Creek, Donovan Creek and the lower reaches of the Big Quilcene. The most appropriate areas for development are limited to Port Townsend and the east side of the Quimper peninsula (Figure 3).

Therefore, alteration to water flow processes in rural areas (except Chimacum/Quimper peninsula) was found to be low to moderate. There are two main stressors present in rural and resources lands included nutrient loading into streams (and ultimately the marine areas) from farms located in the valleys, and clearing of mature forests either for commercial forestry or where the land is converting from forestry to other uses. Results of the marine shoreline characterization indicated that it was in good condition despite the relatively higher concentration of residential and some commercial uses there. The shoreline function scores on average are moderate. There are a few areas that are heavily damaged and modified. The primary threats to the healthy functioning of the shoreline areas are a loss of nearshore riparian habitat due to mainly residential development, continued bank armoring, and effects from upland watershed stressors. These upland watershed stressors include nutrient-loading into water from agriculture, and overwater structures. The Port Townsend shoreline is heavily impacted, due to significant alteration of sediment processes (i.e. isolation of feeder bluffs, shoreline armoring and breakwaters/groins).

In terms of water quality protection, although the County does not have an NPDES permit, it has adopted the 2004 Department of Ecology Stormwater Manual and, in last few years, has begun to develop stormwater comprehensive planning and an extensive outreach and education campaign through a contract with WSU Extension, and is working on a low impact development ordinance. Port Townsend is in the process of reviewing the DOE Stormwater Manual for adoption.

**Overall Findings and Recommendations:**

1. Understanding processes at a watershed scale will improve land use planning and management toward the goal of protecting ecosystem processes, structures and functions for the long-term health of Puget Sound. It will also help identify and prioritize the best areas for restoration and protection so that investments and efforts are made strategically, with better results.
2. The PSP should consider funding a focused, rapid assessment\textsuperscript{48} pilot project (e.g., similar to Birch Bay) in areas across Puget Sound to determine where there is the greatest restoration opportunity and highest risk to resources. As part of this work, the PSP should convene multiple local stakeholders and agencies and perform a specific landscape analysis to select the future development/resource management scenario that best protects and restores the terrestrial and marine ecosystems. The results of the analysis should be compared to existing GMA Comprehensive Plans or other land use planning documents (including salmon recovery or other species recovery plans) to see where land use conflicts are likely to place marine and terrestrial ecosystems at risk of degradation.

3. The PSP should encourage or require that changes be made to adopted plans or that new plans be adopted to ensure the long-term protection of these natural resources. Ideally, the results of this rapid assessment process should lead to a new or revised system of permitting or incentive programs which encourage protection. For example, where protection outcomes and required protection methods are described in particular detail, streamlined permitting processes could be offered to developments following such methods. In addition, the plans could identify in advance the best areas for off-site mitigation (protection and restoration), the mechanisms for accomplishing such mitigation and what the monitoring requirements would be. Such an approach requires the equal participation and endorsement by key state and federal agencies in conjunction with local planners and citizens at the planning level.

4. Characterization of wildlife at a landscape scale must be part of watershed characterization efforts. This includes identifying core species and their critical habitat areas, connectivity of wildlife patches and designation of wildlife corridors as part of critical areas.

5. PSP needs to facilitate the storage and maintenance of watershed information and make it accessible via the web in various formats to citizens. We need to provide many more incentives to local agencies, citizens and landowners for conducting characterizations and preparing watershed based plans. This includes demonstrating how to integrate GMA and SMA planning efforts.

6. The PSP should fund an effectiveness study relative to the restoration of eelgrass beds in the east Jefferson County delta.

\textsuperscript{48} The term "rapid assessment" is meant to convey the fact that this work would be done quickly, in 12-18 months time with a focused work program using technical staff trained to perform this type of work and land use planners and/or attorneys with extensive practical knowledge of Washington’s land use and environmental regulations. We note that there are tradeoffs associated with speed. However, these assessments are seen as an urgent first step toward preserving the intact areas vital for a healthy Puget Sound, while scientists perform longer term studies that will tell us more about the Sound and where additional effort is needed.
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<th>GMA Land Type:</th>
<th>General Habitat</th>
<th>Projected Population Growth</th>
<th>Upland /Terrestrial Habitat Status</th>
<th>Marine Areas Status</th>
<th>Freshwater Status</th>
<th>Biodiversity Wildlife networks</th>
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<td>UGA</td>
<td>Status: The UGA covers 11,332 acres; 4,466 acres are inside the city. The area has Moderate permeability. There are fewer streams, wetlands in this area. Port Townsend generally, has a low importance for water processes, and is lowest in the wetland ratings for the County. This is due to the fact that it has no deeper permeable deposits, lower rainfall and less precipitation delivery. Stressors: The area is “highly altered” due to impervious surfaces, lost forest cover, and roads. Main concerns: forest clearing; increasing impervious surfaces.</td>
<td>UGA: 10,227 Yr. 2000 13,329 Yr. 2024 City: 8,344 Yr. 2000</td>
<td>64% of overall watershed is forested. (Quimper Peninsula), but, Port Townsend Bay area has 20.6% of land in impervious surfaces. The downtown core is built on fill. There is an existing marina at Port Hudson and ____. There are many docks and, over-water structures in the city. The entire shoreline is altered, except for Fort. Worden, which has intact feeder bluffs. There are kelp beds in NW corner. Downtown is the main seawall/armored area. There are a few, small streams in this area and Kai-Tai Lagoon. The lagoon is a transition wetland; it was previously part of estuary before it was cutoff. Kai-Tai Lagoon is a high restoration priority to return to tidal influence.</td>
<td>Upland: Marine Areas Status: Water quality is generally good in the bay. Stormwater is the main potential source of nonpoint pollution. The sewer system is located near Fort Worden and the outfall pipe goes into good mixing zone in Admiralty Inlet.</td>
<td>High biodiversity score due to lots of shorebirds, waterfowl; and marine mammals.</td>
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<td>Port Townsend</td>
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<td>Marine Areas Status</td>
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Comments re: Water Processes Protection & Restoration
City could remove some docks; improve circulation in marinas by adding outlet where dead-end. Restore estuary lagoon; Continue protecting shoreline functions (esp. northside bluffs) based on total function, add density here; (Need to consider quality of life issues, transportation, lack of access to jobs or economic engine, etc.) Encourage upland development in peninsulas like this – as long as you take care of the shorelands. Big incentive here for TDR may be a big help here – offsite mitigation should be considered in restoration areas in other basins especially in the Chimacum Valley sub-basins.
<table>
<thead>
<tr>
<th>GMA Land Type:</th>
<th>General Habitat Status and Stressors on Water Processes</th>
<th>Projected Population Growth</th>
<th>Upland/Terrestrial Habitat Status</th>
<th>Marine Areas Status</th>
<th>Freshwater Status</th>
<th>Biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>Port Hadlock/Irondale</td>
<td>UGA: 2,553 Yr. 2000</td>
<td>The area consists of pre-1900's clearing of the watershed, a resulting loss of forest cover from logging and rural residential development. Today, the area has 614 acres designated forestland; 70% forest cover. The Chimacum area scores high in importance for hydrologic processes primarily due to the presence of wetlands and floodplains and relatively large areas of permeable deposits and moderate rainfall levels. UGA is the host for entire Chimacum Watershed, which is impacted by forestry and agricultural impacts. Shellfish area threatened at the mouth of the creek at Port Hadlock. Aquifer recharge area with significant water supply wells covers part of the area.</td>
<td>Primary stressor in this area is fill and bulkheads. Up to 75% of shorelines in this area are altered by shore armoring (bulkheads). In addition, at the mouth of Chimacum Creek there are high concentration levels of nitrates from upland agriculture which cause seaweed blooms that kill eelgrass beds.</td>
<td>There is a net movement of surface water that recharges deep aquifers in this area. The area has sustained wetland alteration and loss over time, primarily from drainage ditches. Here, wetland restoration could help with removal of Nitrate Nitrogen through de-nitrification which would otherwise be transported to the bay and contribute to algal blooms and potentially low DO problems.</td>
<td>High biodiversity opportunity in this UGA because it sits at the mouth of Chimacum Creek. The estuary presence drives score from low to moderate as move upstream (outside UGA).</td>
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<td></td>
<td>Habitat Status:</td>
<td>4,906 Yr. 2024</td>
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<td>The UGA size is 1,320 acres, with 1,035 in the lower watershed. The UGA is rated &quot;moderate&quot; for permeability and for water processes. Total impervious area is good at less than 6% in the lower watershed. UGA 1320 acres; 1035 lower watershed; Stressors: Rated at “high risk” for significant loss of habitat due to density and growth pressures. Also groundwater withdrawal issues are serious in Chimacum Creek. The area looks rural on zoning maps, but actual build out shows there is only 24 acres of commercial agriculture here, and 2,880 acres of rural residential development. Zoning is R-5 and R-10 but the area is already highly parcelized into smaller lots. This is place to try to hold the line against more density &amp; growth.</td>
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<td>City:</td>
<td>3,442 Yr. 2000</td>
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<td>5,598 Yr. 2024</td>
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<td>Comments:</td>
<td>Complete the instream flow rules. Hold line on UGAs. Enforce zoning. Solve nutrient problem from upland ag sources. (Similar to urban/suburban creeks) Remove inter-tidal fill; Minimize or remove bulkheads; investigate nutrient problem (look at residential septic, too) Use incentives such as TDRs, etc. to prevent build out of small parcels in rural area. Look at Montgomery County, MD program. Could be good receiving area for off-site mitigation projects caused by impacts to wetlands from Pt. Townsend. Endorse community stewardship program for restoration.</td>
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<tr>
<td>GMA Land Type:</td>
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| Urban/Other   | Port Ludlow (master planned resort)                   | 1,530 FY 2000, 3,783 by 2024| This area has high importance due to its very permeable soils and current state of low alteration and low stressors. | There is a marina, bank armoring and over-water structures. | This area has few wetlands and lower stream density relative to the rest of the county so has lower importance for water flow processes. | Biodiversity is rated at "medium" value within Port Ludlow. The presence of these species shows an indicator of ecosystem health.

**Habitat Status:** At 23 acres in size, Port Ludlow has localized, highly urban conditions with local impacts, but within an overall rural context. Most of the surrounding area is in a forested condition.**Stressors:** Containing growth and preserving hydrologic processes surrounding it. There is a need to limit habitat fragmentation and roads crossings.

The area is expected to more than double in size with master planned resort final phase build out.

The major concern here is clearing for development.

Hydrologic functions are low on the inner part of the resort and rise to moderate as you move further out toward the edge of the resort. Water quality in the bay is monitored by the owners and consistently meets class AA standards, except in summer when there is a spike in fecal coliform.

This area has few wetlands and lower stream density relative to the rest of the county so has lower importance for water flow processes.

No specific data here.

**Biodiversity:** Rate at "medium" value within Port Ludlow. The presence of these species shows an indicator of ecosystem health.

**Comments:** Zoning works if no rural cluster density bonuses (avoid sprawl); reduce forest loss/soil disturbance to protect water quality. Stay back from bluffs to prevent need for armoring. (see stressor list- use tools to limit or avoid) Implement the 20 acre zoning on the outside the devel.

Use LID; Green Build standards. For marinas, docks or other overwater structures, build or rebuild use the newest design see Diefendorfer et al. SMA update is opportunity; Culturally, they like incentives - See the list; PBRS, etc. Conservation easements, etc. Need to protect water quality. Subdivisions have slowed.
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<tr>
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<th>Projected Population Growth</th>
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<th>Biodiversity Wildlife networks</th>
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<tbody>
<tr>
<td>Rural Lands</td>
<td>Habitat Status:</td>
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<td>Glacial terraced areas: (Chimacum, Tarboo, Thorndyke, Boltron, Torindos)</td>
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<td>Higher permeability in these areas is important to groundwater flow processes and discharge to aquatic systems.</td>
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<td>Stressors: 65% forest cover can likely be maintained; High percentage of forest intact.</td>
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<td>High risk of conversion to rural uses. Loss forest cover; roads; increase in impervious. Surfaces; Will cause:</td>
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<td>Stream channel degradation. Water quality degradation, mostly from small hobby farms.</td>
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<td>30% new growth projected here. 4,149 FY 2024</td>
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<td>Hydrologic processes in the Duckabush and Dosewallips are under most stress from residential development. The channel migration zone and estuarine delta areas are at high risk of loss if not acquired or otherwise protected. Upstream areas in the Quilcene are at risk from residential development. Lower valley alluvial stream bases are really important.</td>
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<td>Marine shoreline areas are in good shape. The biggest stress here is in Brinnon area, due to road crossing &amp; development. Waterfront development is a stressor, but lower than elsewhere.</td>
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<td>Opportunities to protect processes exist. Recommend that they don’t block streams, avoid road crossings in estuaries. There is a good fish corridor from South don’t armor or disturb nearshore riparian areas. In Dabob Bay, there is some shellfish production and fairly good water quality there.</td>
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<td>There is a large concentration of R-5 zoning in marine shorelines. This can work with proper setbacks.</td>
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<td>Quilcene Bay – relatively high biodiversity on the western and northern portions. In Dabob Bay, where Tarboo Creek comes in, there is high biodiversity. Extending inland up into the Quilcene Valley, biodiversity is high.</td>
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**Comments:**

Regulations - On hobby farms, encourage or require the use of BMPs or the NRCS Field Office Technical Guide and farm plans to prevent water quality impacts. There is a potential for increased density in these rural areas. The county should consider down-zoning or require merging of lots to develop. If the County intends to retain R-5 zoning or less, development needs to minimize impacts by using LID techniques where appropriate, minimizing road crossings; limiting clearing; use watershed context to impose protections. R-5 zoning may not make sense from a habitat standpoint in floodplains or riverine areas. Larger parcels may provide longer term protection of habitat in those areas. In the R-5 zone, a mix of non-regulatory incentives and education about protection may work better to obtain public support for protection.
### Forest

<table>
<thead>
<tr>
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<th>Freshwater Status</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Habitat Status:</strong> This area consists of 88,000 acres of state/private lands. Large portions are in National Forest, and Commercial or Rural Forest. Zoning is 1du/40 acres; <strong>Stressors:</strong> Commercial forest activities. Logging has impacts on forest cover; can impact riparian areas and unstable slopes result in erosion and sedimentation and resulting water quality problem.</td>
<td>Small in-holdings of residential development in Little Quilcene and up into forest on Dosewallips and Duckabush.</td>
<td>Overall, for these areas hydrologic processes are altered from commercial forest practices, but not severely degraded and are still intact. Forest roads management practices and water quality need to be dealt with. The Quimper Peninsula has high to moderate permeability, but scored lower for wetland importance, it is currently in a highly altered state due to road density, forest clearing. There is less impervious surfaces here and a moderate to higher potential for restoration</td>
<td>Water quality is impacted from sedimentation resulting from clearing. There are some water temperature effects (temperatures are warmer in estuaries).</td>
<td>Quilcene – Variable condition. See map. Tends to increase with elevation up the rivers</td>
<td><strong>Comments:</strong> Forest Practices Act is the primary tool here, plus ESA and CWA. The FPA doesn’t address goal of maintaining hydrologically mature forests. Encourage DNR to complete a model for hydrologic impacts from logging. Encourage selective thinning; Use clearing limits; consider cap and trade systems and low impact development techniques to limit stormwater impacts and loss of forest cover. The Northwest Forest Plan is being implemented by the forest service. HCPs may govern other, private lands. Need more incentives (e.g., cap and trade systems or other set aside incentive programs to protect forest cover in the most important areas).</td>
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</table>
## GMA Land Type: Natural Resource

### General Habitat Status and Stressors on Water Processes

### Projected Population Growth

### Upland /Terrestrial Habitat Status

### Marine Areas Status

### Freshwater Status

### Biodiversity Wildlife networks

#### Agricultural Lands

**Status:** Agricultural lands comprise 4,400 acres, mostly in the Chimacum Valley and there is a small amount in Salmon and Snow Creeks that mostly consists of silage, grain, livestock and grazing. There used to be extensive dairies, but only 1 remains. Most farms have livestock, growing hay or specialized vegetables, producing cheese, or fruit.

The County recently re-designated 3,900 acres as long-term commercial agricultural land of local importance.

**Stressors:** Water quality impacts from nutrient loading into streams and ultimately nearshore waters.

The upland farm areas comprise 4,400 acres mostly in the Chimacum Valley and there is a small amount in Salmon and Snow Creeks.

Major impacts to habitat are from nutrient and nitrates. Nearly all farms are located next to creeks, which then run downstream into the nearshore areas. Pollutants can also be transported through aquifers. The valley areas are significant sources of nitrification.

Varies across agricultural lands. Water quality is high in Chimacum area, low through other agricultural lands and improves again to high through the Forest Protection District.

**Comments:** Consider using the NFRCS Field Operating Technical Guide manual and encourage or require the use of farm plans to lessen the impacts overall from farms. Wetland restoration would greatly assist in nitrogen reduction. Consider offering new incentives in these areas, such as providing credits on peat soils, etc.
<table>
<thead>
<tr>
<th>GMA Land Type: Natural Resource</th>
<th>General Habitat Status and Stressors on Water Processes</th>
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<th>Freshwater Status</th>
<th>Biodiversity Wildlife networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>Status: There are presently no lands designated for mining in the County.</td>
<td>N/A</td>
<td>N/A</td>
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<td>Stressors: There is a single proposal for the Shine Quarry, which has not yet been approved.</td>
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Figure 1. Important Areas for the Hydrologic Process. Dark blue represents a score of high importance; medium blue represents a score of medium importance and light blue represents a score of lower importance.
Figure 2. Sub-basins with a high level of alteration are shown in “red” and areas with low alteration in “green.”
Figure 3. Priority areas for protection are shown in “green,” for restoration in “yellow,” and for development in “red.”
A-3.0 Detailed Analysis Matrix

Figure A-13. Detailed analysis matrix for creating final restoration and protection map for the hydrologic and denitrification processes. (Based on figure 8)

Matrix Scoring Scheme for Hydrologic Process

Figure A-13 depicts the detailed matrix for synthesizing the results of the importance and alteration maps for the hydrologic process (Figures 4 and 5). The matrix is based on watershed-based research indicating that areas with low levels of alteration to watershed processes should be protected and areas with higher levels of alteration to processes with a higher level of importance should be restored (Stanley et al. 2005).
Appendix P1-1: Summary of Key Environmental Regulations

The following is a non-exhaustive list of key regulations that exist through federal, state or local laws and regulations that have effect in the Puget Sound region. These laws and regulations are highlighted for the reason that they are tools that either directly or indirectly provide protection for some habitat-forming processes, structures or functions or, more generally, the needs of particular species of animals or fish. As noted in the Responses to Questions P1 and P2, there is no single regulation that provides protection from an ecosystem perspective as we have defined it. Instead, the framework of laws and regulations that exist in Puget Sound is largely fragmented, occasionally overlapping and mostly focused on individual parcels (site scale) or individual species.

Federal Laws

There are literally hundreds of federal laws that affect marine and ocean areas. There are scores more that affect individual species and upland terrestrial areas and freshwater habitats. For purposes of brevity, the Topic Forum presents below a summary list of some of the laws that have an obvious impact in Puget Sound, in terms of their regulatory effect.

The Endangered Species Act. Endangered Species Act of 1973, Pub. L. No. 93-205, 87 Stat. 884, as amended by Pub. L. No. 97-304, 96 Stat. 1411 (1982), See, 16 U.S.C. 1531-1541; ESA Regulations: See, 50 C.F.R. Part 17 (USFWS) and 50 C.F.R. Part 222 (NMFS). The Act protects species listed under the ESA, as well as critical habitats, from hunting, transport, or other harassment. Endangered species are managed by the U. S. Department of the Interior through the U.S. Fish & Wildlife Service (USFWS) and by the National Oceanic and Atmospheric Administration (NOAA Fisheries). Under the ESA, the following strategies are used:

- Directs all federal agencies to use existing authorities to conserve listed species and ensure their actions do not jeopardize the survival of listed species;
- Requires preparation of Recovery Plans;
- Prohibits “take” of a listed species (absent certain exceptions) (Section 9);
- Requires federal agency consultation with USFWS and NMFS (Section 7);
- Designates critical habitat;
- Implements international treaty, the Convention on International Trade in Endangered Species of Wild Fauna and Flora; and
- Allows for preparation of Habitat Conservation Plans that balance development with species conservation (Section 10).

The main protection provided for species listed under the ESA is found in Section 9, known as the “no take” provision. The term “take” is broadly defined to mean “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in such conduct.” (16 U.S.C. Section 1532(19)). In analyzing the legislative history of this definition, the 9th Circuit Court of Appeals noted that the Senate Report on the Act stated that the term “take” included “...every conceivable way in which a person can ‘take’ or attempt to ‘take’ any fish or wildlife.” Palila v. Hawaii Dept. of Land and Natural Resources, 852 F.2d 1106, 1108 (1988) (“Palila IV”).

In 1995, the U.S. Supreme Court upheld the federal rule promulgated by the USFWS interpreting the term “harm” to include “significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.” Babbitt v. Sweet Home Chapter of Communities for a Greater Oregon, 115 S. Ct. 2407 (1995). (See, 50 C.F.R. Section 17.3(c) (USFWS definition of “harm”). NMFS adopted a similar definition of the term “harm” for the habitat of anadromous fish and marine mammals. (See, 63 Fed. Reg. No. 84 at pp. 24148 - 24150, (May 1, 1998)). The key difference in their definition is that it expands the definition of harm to include the terms breeding, spawning, rearing, migrating, feeding or sheltering.
A key provision of the Act is its Section 7 consultation requirement. Section 7 requires review of activities to determine whether they are likely to adversely affect the listed species. If so, further consultation and the preparation of a formal biological opinion is required to ensure that the activity will not jeopardize the continued existence of the species. See, 16 U.S.C. Section 1536(a)(2) and 50 C.F.R. Section 402. Section 7 applies to all federal agencies (and the state/local governments or private parties that have a nexus with a federal agency's action). An “action” that can trigger Section 7 review means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or on the high seas. The term “action” includes, but is not limited to: (i) actions intended to conserve listed species or its habitat; (ii) the promulgation of regulations; (iii) the granting of licenses, contracts, leases, easements, rights-of-way, permits, grants-in-aid; or (iv) actions directly or indirectly causing modifications to land water or air. Pacific Rivers Council v. Thomas, 30 F.3d 1050, 1054 (9th Cir. 1994). The agency is required to insure that such actions are not likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of its habitat. See, Tennessee Valley Authority v. Hill, 437 U.S. 153, 98 S.Ct. 2279, 57 L.Ed.2d 117 (1978).

Section 10 is a tool often used by large landowners to continue activities (such as commercial forestry), that may have an incidental impact on a listed species. It authorizes habitat conservation plans (HCPs). See, 16 U.S.C. 1539(a)(2). The “taking” must be incidental to and not the purpose of, the carrying out of an otherwise lawful activity. The applicant must submit a conservation plan based upon the best scientific and commercial data available which specifies: (a) the anticipated impacts which will likely result (i.e., the amount, extent and type of anticipated taking) from the proposed activity on the species or stocks; (b) the steps the applicant will take to monitor, minimize and mitigate such impacts; (c) the funding which will be available to implement such measures; (d) the alternative actions to the taking which were considered, and the reasons why they are not being used; and (e) such other measures as the agency may determine are necessary and appropriate for the conservation of the species or stocks. In order to approve an HCP, the Service must determine that the taking will be incidental, that the applicant will, to the maximum extent practicable, monitor, minimize and mitigate the impacts of such taking and, finally, that the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild.

Coastal Zone Management Act of 1972. Under the Coastal Zone Management Act, all federal permitted actions, such as Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbor Act, must be evaluated for consistency with the CZM Program. Federally owned lands or lands held in federal trust are exempt from the state’s coastal plan, at least with respect to direct federal activities. For a comprehensive review of the CZMA and other important laws, refer to the U.S. Commission on Ocean Policy’s Final Report at Appendix 6 “A review of U.S. Coastal and Ocean Law”.

Federal Clean Water Act (CWA). The Act prevents or permits discharges of pollutants to waters of the United States;

- NPDES permits are required for direct and indirect (point and nonpoint) source discharges into navigable waters;
- NPDES permits cover many activities including industrial, construction (1 acre or larger), municipal activities (10,000 in population or greater), boatyards, sand and gravel operations, etc.;
- Section 404 of the Act regulates filling but not dredging, draining or clearing of wetlands; and
- The Act is administered by the Environmental Protection Agency (EPA) except in states which have chosen to become the state administrator, such as here in Washington. By law, the Clean Water Act is implemented by the Washington State Department of Ecology.


Wild and Scenic Rivers Act. The Act categorizes rivers according to their value as wild or scenic and, depending on the designation granted, provides heightened regulatory protection against alteration or impacts from human activities. This law is administered by the U.S. Forest Service.

National Environmental Policy Act (NEPA). For a comprehensive review of NEPA and other important laws, refer to the U.S. Commission on Ocean Policy’s Final Report at Appendix 6 “A review of U.S. Coastal and Ocean Law”. [Note: This summary was prepared by the U.S. Commission on Ocean Policy as cited above].

The National Environmental Policy Act (NEPA)\(^49\) has been called many things through its three decades of existence, including the Magna Carta or centerpiece of environmental law, and the “most important [of our] environmental legislation.”\(^50\) Signed into law in 1970 with the inspiring goal to “create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans,”\(^51\) NEPA “sets forth a ringing and vague statement of purposes.”\(^52\) This vagueness grew into a powerful tool for challenging federal agency actions that ignored potential environmental impacts. Federal agencies’ obligation to comply with NEPA is a common issue in federal environmental and natural resources law, including ocean and coastal law.

Aside from its statements of policy objectives, NEPA’s “action-forcing” mechanism is in Section 102, which requires all federal agencies to include a detailed statement of the environmental impact of all “major federal actions significantly affecting the quality of the human environment.”\(^53\)

A “major” federal action is one that requires substantial planning, time, resources, or expenditure that a federal agency proposes or permits. Through conducting Environmental Assessment (EA) and Environmental Impact Statement (EIS) reviews, federal agencies are required to consider environmental impacts before action is taken.\(^54\) Federal agencies are also required to consider the direct, indirect, and cumulative impacts of regulated federal activities.\(^55\)

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\(^49\) 42 U.S.C. § 4332(2)(C)


\(^51\) 42 U.S.C. § 4331(a).

\(^52\) Rodgers at 801.

\(^53\) 42 U.S.C. § 4332(2)(C)

\(^54\) The Environmental Impact Statement is a detailed statement prepared by the responsible official within the relevant federal agency that addresses: “(i) the environmental impact of the proposed action; (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented; (iii) alternatives to the proposed action; (iv) the relationship between local short-term uses of man’s environment and the maintenance and enhancement of long term productivity; and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.” 42 U.S.C. § 4332(2)(C). Where there is a question as to whether a particular government action requires an environmental analysis, regulations implementing NEPA promulgated by the Council on Environmental Quality (CEQ) require the federal agency seeking to undertake the action to prepare an Environmental Assessment (EA). An EA is a document that “[b]riefly provide[s] sufficient evidence for determining whether to prepare an . . . [environmental analysis] or a finding of no significant impact.” After preparation of the EA, if the agency makes a finding of no significant impact (FONSI), then preparation of an EIS is not necessary. CEQ’s NEPA regulations are at 40 C.F.R. Part 1500 et seq.

\(^55\) See 40 C.F.R. §§ 1502.16, 1508.7, and 1508.8.
In addition, NEPA mandates coordination and collaboration among federal agencies. Specifically, "prior to making any detailed statement, the responsible federal official shall consult with and obtain the comments of any federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved." Many federal agencies, including those with substantial ocean and coastal programmatic responsibilities, such as NOAA, EPA, and the U.S. Department of the Interior’s Fish and Wildlife Service (USFWS)—and state agencies, nongovernmental organizations, and members of the public—frequently comment on NEPA documents. The Council on Environmental Quality (CEQ) in the Executive Office of the President, established under NEPA, plays the role of interagency dispute resolution mediator when necessary.

This is where NEPA’s mandates end. The Supreme Court has declared that NEPA’s reach is procedural rather than substantive: NEPA cannot “mandate particular results but only prescribe the necessary process.” Thus, once a federal agency has completed the detailed statement that NEPA requires, the agency may continue its proposed activity regardless of the actual impact upon the receiving environment, although other legal authorities still apply and might preclude or limit the federal agency's action.

The Bureau of Land Management, U.S. Department of the Interior. As noted in Response to Question P1, the federal Bureau of Land Management manages multiple uses of 400,000 acres of federal lands in Washington State. In order to understand the important role that the BLM can play in Puget Sound recovery, we provide a short history of its regulatory authority since its inception.

The BLM’s roots go back to the Land Ordinance of 1785 and the Northwest Ordinance of 1787. These laws provided for the survey and settlement of the lands that the original 13 colonies ceded to the federal government after the War of Independence. As additional lands were acquired by the United States from Spain, France, and other countries, Congress directed that they be explored, surveyed, and made available for settlement. In 1812, Congress established the General Land Office in the Department of the Treasury to oversee the disposition of these federal lands. As the 19th century progressed and the nation’s land base expanded further west, Congress encouraged the settlement of the land by enacting a wide variety of laws, including the Homesteading Laws and the Mining Law of 1872.

These statutes served one of the major policy goals of the young country-- settlement of the western territories. With the exception of the Mining Law of 1872 and the Desert Land Act of 1877 (which was amended), all have since been repealed or superseded by other statutes.

The late 19th century marked a shift in federal land management priorities with the creation of the first national parks, forests, and wildlife refuges. By withdrawing these lands from settlement, Congress signaled a shift in the policy goals served by the public lands. Instead of using them to promote settlement, Congress recognized that they should be held in public ownership because of their other resource values.

In the early 20th century, Congress took additional steps toward recognizing the value of the assets on public lands and directed the Executive Branch to manage activities on the remaining public lands. The Mineral Leasing Act of 1920 allowed leasing, exploration, and production of selected commodities such as coal, oil, gas, and sodium to take place on public lands. The Taylor Grazing Act of 1934 established the U.S. Grazing Service to manage the public rangelands. The Oregon and California (O&C) Act of August 28, 1937, required sustained yield management of the timberlands in western Oregon.


57 Robertson v. Methow Valley Citizens Council, 490 U.S. 332, 350 (1989); see also Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, 435 U.S. 519, 948 (1978); Kleppe v. Sierra Club, 427 U.S. 390 (1976). The Court stated that once an agency has made a decision subject to NEPA’s procedural requirements, “[t]he only role for a court is to ensure that the agency has taken a ‘hard look’ at the environmental consequences; it cannot ‘interject itself within the area of discretion of the executive as to the choice of the action to be taken.’” Id. at 410.
In 1946, the Grazing Service was merged with the General Land Office to form the Bureau of Land Management within the Department of the Interior. When the BLM was initially created, there were over 2,000 unrelated and often conflicting laws for managing the public lands. The BLM had no unified legislative mandate until Congress enacted the Federal Land Policy and Management Act of 1976 (FLPMA), Public Law 94-579 94th Congress.

In enacting the FLPMA, Congress recognized the value of the remaining public lands by declaring that these lands would remain in public ownership. Congress also gave us the term “multiple use” management, defined as “management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people.” The FLPMA is extremely influential in governing the BLM’s management of federal lands. The effect that the adoption of the FLPMA has had across the U.S. is illustrated in the table below.

| The BLM’s Management of Public Lands  
A Snapshot of Pre- and Post-FLPMA Management 1976 & 2000 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highlighted Area</strong></td>
<td><strong>Pre-FLPMA 1976</strong></td>
<td><strong>Post-FLPMA 2000</strong></td>
</tr>
<tr>
<td>Acres Managed</td>
<td>450 million surface 822 million mineral estate administered</td>
<td>264 million surface 700 million mineral estate administered</td>
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<tr>
<td>BLM Employees</td>
<td>4,530</td>
<td>10,000</td>
</tr>
<tr>
<td>Types of Primary BLM Disciplines (not comprehensive)</td>
<td>Range Conservationists, Land Surveyors, Geologists, Foresters, Administrative Assistants</td>
<td>In addition to types of jobs in 1976: Wildlife Biologists, Wild Horse and Burro Specialists, Recreation Specialists, Economists, Hydrologists, Archaeologists, Sociologists, and Land Use Planners</td>
</tr>
<tr>
<td>Proximity of BLM lands to communities</td>
<td>Records show that in the West, cities having a combined population of 35 million people are within a three-hour drive of 66 million acres of BLM lands.</td>
<td>More than 4,100 communities with a combined population of 22.2 million people are located within 25 miles of BLM lands</td>
</tr>
<tr>
<td>Land Exchanges Patents or deeds issued</td>
<td>53 36,991 acres</td>
<td>244 135,850 acres</td>
</tr>
<tr>
<td>Recreation sites Managed by BLM Fee Sites</td>
<td>326 0</td>
<td>3,191 335</td>
</tr>
<tr>
<td>Wild and Scenic Rivers</td>
<td>3 Wild and Scenic Rivers</td>
<td>36 Wild and Scenic Rivers</td>
</tr>
<tr>
<td>Highlighted Area</td>
<td>Pre-FLPMA 1976</td>
<td>Post-FLPMA 2000</td>
</tr>
<tr>
<td>------------------------------------------------------</td>
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<td>-----------------</td>
</tr>
<tr>
<td>Areas of Critical Environmental Concern Acres</td>
<td>0</td>
<td>838</td>
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<tr>
<td></td>
<td>0</td>
<td>14,045,540</td>
</tr>
<tr>
<td>Historical &amp; Archeological Properties recorded Acres inventoried</td>
<td>11,076</td>
<td>235,574</td>
</tr>
<tr>
<td></td>
<td>1,133,956</td>
<td>14,416,221</td>
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<tr>
<td>Percentage of country's onshore oil and natural gas provided from federal lands</td>
<td>6% Oil and Gas</td>
<td>11% Natural Gas</td>
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<tr>
<td></td>
<td>5% Oil</td>
<td>5% Oil</td>
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<tr>
<td>Millions cubic feet (Mcf) of Natural Gas Produced on federal Land</td>
<td>1,080 million Mcf</td>
<td>2,139 million Mcf</td>
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<tr>
<td>Barrels of Oil Produced on federal Land</td>
<td>168,000,000</td>
<td>108,000,000</td>
</tr>
<tr>
<td>Coal Production on federal land - Total (short tons-2000 lbs) - WY Coal Production</td>
<td>54,782,326</td>
<td>404,787,030</td>
</tr>
<tr>
<td></td>
<td>325,180,000</td>
<td></td>
</tr>
<tr>
<td>AUMs livestock grazed</td>
<td>10.1 million</td>
<td>9.8 million</td>
</tr>
<tr>
<td>Acres of National Conservation Areas and National Monuments</td>
<td>57,000 acres</td>
<td>19 million</td>
</tr>
<tr>
<td>Number of Threatened and Endangered species</td>
<td>177 species of animals and plants</td>
<td>511 species of animals and 736 species of plants</td>
</tr>
<tr>
<td>Highlighted Area</td>
<td>Pre-FLPMA 1976</td>
<td>Post-FLPMA 2000</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Acres of Designated Wilderness and Wilderness Study Areas Managed by BLM</td>
<td>0</td>
<td>23,445,495</td>
</tr>
</tbody>
</table>

Source: Bureau of Land Management: http://www.blm.gov/flpma/snapshot.htm

**State Laws**

There are numerous state laws that are designed to protect habitat. We have selected a few of the major regulatory programs for emphasis below. This is not an exhaustive list, but is an attempt to focus on the tools that are the most widely used in Puget Sound to protect habitat at some scale, even if not at an ecosystem scale. Other laws and regulations are described in Response to Question P-1.

State Environmental Policy Act. SEPA recognizes “that each person has a fundamental and inalienable right to a healthy environment.” RCW 43.21.020(3). SEPA creates both procedural and substantive mandates which can be used to require disclosure of significant adverse environmental impacts, mitigation of those impacts and even denial of permits. The requirements of SEPA are carried out at the state and local government level. A similar law is imposed at the federal level, the National Environmental Policy Act (NEPA). See, 42 U.S.C. Section 4331.

Shoreline Management Act. The SMA is quite short and depends on a system of state and primarily local control (including environment designations, development standards and regulations), to be implemented. Its basic premise is that no activity is allowed on the state’s shorelines that is inconsistent with the Act or local implementing regulations and that development result in “no net loss” of shoreline functions. See, Wash. Real Property Deskbook, 3d Ed. Volume VI, Chapter 93. The regulatory reach of the SMA on aquatic systems is fairly broad. It applies to all shorelines of the state, marine waters, certain larger streams, large lakes and water reservoirs. It also includes shorelands extending 200 feet from the ordinary high water mark, and all wetlands and river deltas associated with streams, lakes and tidal waters subject to the Act.58 However, the SMA is not merely a protective regulation. It balances development and preservation near shorelines, establishes a priority of uses for the shoreline, including an emphasis on water-dependent uses and public access; and the reduction of adverse environmental impacts of development and other activities occurring in the shoreline zone. See, Wash. Real Property Deskbook, 3d Ed. Volume VI, at 93-11.

To implement the Act, local governments must prepare Shoreline Master Programs based on standards set forth in the Shoreline Master Program Guidelines (WAC 173-26). Recent revisions to the Shoreline Master Program Guidelines require local governments to use an ecosystem or landscape approach when updating their master programs. Ecosystem wide processes and ecological functions must be characterized and the linkages with shoreline functions described. From this characterization and analysis, measures must be identified to protect and restore healthy and degraded shoreline processes and functions. Additionally, the environment designations, policies, development

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58The SMA applies to “all shorelines of the state” which include both shorelines and shorelines of state-wide significance, marine waters of the state together with the lands underlying them out to the western boundary of the state in the Pacific Ocean, to streams with a mean flow of 20 cfs. or more, and to lakes larger than 20 acres in area and to water reservoirs. The SMA also applies to associated “shorelands” of all of these shorelines. Shorelands are defined as those lands extending landward for 200 feet in all directions as measured on a horizontal plane from the Ordinary high water mark, floodways and contiguous floodplain areas landward 200 feet from such floodways, and all wetlands and river deltas associated with the streams, lakes and tidal waters which are subject to the Act. Id. See, Ch. 90.58 RCW. The federally approved Coastal Zone Management Program (CZMP) for Washington contains all of the local shoreline plans, except that the coastal zone plan does not include rivers and wetlands. Id.
standards and regulations must be based on the characterization (which includes a comprehensive inventory of shoreline conditions).

Local governments are also required to monitor the implementation of their SMP and demonstrate that there will be “no net loss” of shoreline function. Recognizing that restoration will play a central role in the recovery of Puget Sound ecosystems, the guidelines stipulate the preparation of a restoration plan. The restoration plan is also based on the characterization. The Department of Ecology (statutory authority to review and approve shoreline plans) is presently encouraging local governments to implement the restoration plan using both regulatory and non-regulatory means. Though the preparation of ecosystem based shoreline plans is a welcome advancement in the state, local governments are not required to implement the results of the characterization outside of the narrow 200-foot-wide shoreline jurisdiction. This is unfortunate, since most processes that drive shoreline functions are located in watersheds that can extend several miles inland from the shoreline.

Forest Practices Act. All private and non-federally owned “forest lands” fall within the purview of the Forest Practices Act (FPA). The current FPA (Chapter 76.09 RCW) was enacted in 1974. In replacing Ch. 76.08 RCW, a reforestation act dating back to 1945, the FPA created a coordinated, statewide system for regulating forest practices, requiring reforestation, and adding protections for water, fish and wildlife. Forest Practices rules impose standards for road construction, snag retention and for protecting streams, stream corridors and certain types of forested wetlands. The FPA requires 15 counties to adopt local regulations governing forest practices on lands which are permanently converting from forestry to other land uses, known as Class IV forest practices, by December 1, 2008. (To date, 11 jurisdictions have not yet enacted ordinances to regulate such activities.) The goal of the FPA is dual: to foster the state’s commercial timber industry and to protect the natural environment. The Act is enforced by the Washington State Department of Natural Resources (DNR) through state regulations promulgated by the Forest Practices Board. Updates to the FPA were added in 1987, as a result of the “Timber, Fish and Wildlife” negotiations conducted by a wide array of stakeholders and state and federal agencies and tribal governments concerned about impacts of forest practices on certain salmon populations listed under the Endangered Species Act. The Forest Practices Act was again amended between 1999 and 2001 with the adoption of the Fish and Forest Agreement. The Agreement was reached to meet the requirements of both the ESA and Clean Water Act. The Forest and Fish Agreement resulted in the modification of rules and regulations related to:

- The protection of riparian areas, unstable slopes and wetlands;
- The construction, maintenance and abandonment of forest roads;
- The application of forest chemicals; and
- The implementation of a monitoring and adaptive management program to ensure that the program adapts over time based on new scientific information.

The Forest and Fish Agreement covers approximately 6.1 million acres of forest land on the west side of the Cascade mountains, including private and state forest lands. Washington’s forest practices program operates under a Habitat Conservation Plan (HCP) pursuant to Section 10 of the ESA, and has been approved by the National Marine Fisheries Service and U.S. Fish and Wildlife Service, providing protections for all listed fish species and seven amphibian species.

There are several other HCPs governing forest practices in Puget Sound on private lands designed to protect aquatic species, as well as other species. They include both private landowners (West Fork Timber Company, LLC, Plum Creek Timber Company, Port Blakely, Green Diamond (Simpson) representing a combined 745,971 acres of land, and

59Forest lands mean “all land which is capable of supporting a merchantable stand of timber and is not being actively used for a use which is incompatible with timber growing.” RCW 76.09.020(6) Merchantable timber means “a stand of trees that will yield logs and/or fiber: suitable in size and quality for production of lumber, plywood, pulp or other forest products, of sufficient value at least to cover all the costs of harvest and transportation to available markets.” WAC 222-16-010.
public landowners (DNR, the City of Seattle and City of Tacoma) representing an additional, combined, 1.7 million acres of land affecting Puget Sound and its rivers.

The Growth Management Act. The GMA now applies to all 39 counties across the state, as well as to the cities located within them. (However, 10 of the 39 counties in the state are only required to adopt measures to designate and conserve natural resource lands of long-term commercial significance and to designate and protect critical areas. They are not required to adopt urban growth areas or comply with the other requirements of the Act). Local governments subject to GMA must now plan for the growth of their communities by adopting comprehensive plans and planning for the infrastructure needs of their communities using 10- and 20-year increments based on the state's population projections.\(^6\) No longer just a guide, local governments must now adopt development regulations (zoning and development standards) that are consistent with those comprehensive plans. The Act requires planning for urban, rural and natural resource lands. (Natural resource lands include areas for forestry, agriculture and mining.) Urban growth boundaries are drawn beyond which dense development is to be prohibited to protect rural and natural resource lands.\(^6\) Finally, the GMA mandates that local governments regulate and protect certain environmental functions and values in “critical areas.” These areas include: fish and wildlife habitat conservation areas, wetlands, aquifer recharge areas, and frequently flooded areas. RCW 36.70A.172.\(^6\)

Hydraulic Project Approval (HPA) program (RCW 75.20.100). The statute protects aquatic habitat, including wetlands, within ordinary high water mark of marine waters, lakes, ponds, and streams. It is administered by the Washington Department of Fish and Wildlife through the issuance of Hydraulic Project Approval permits. The HPA program has significant limitations and is an ineffective tool to protect habitat in most cases.

Water Quality: State and federal stormwater and water quality program; Clean Water Act NPDES- Effect of new nonpoint municipal stormwater permit requirements; local non-pollution ordinances; [See other Topic Forum reports]; Washington State Department of Health Water Supply Systems regulations.

Water Quantity: [See other Topic Forum reports] State Groundwater Code

WDFW Species Protection Rules:

Bald Eagle Protection Rules (WAC 232-12-292) The rules require Washington Department of Fish and Wildlife to identify and protect bald eagle habitat and buffer zones on all non-federal and non-tribal lands in Washington. A process is outlined for protecting habitat via management planning

\(^6\)These plans include future land use maps and land use designations which are consistent with those policies. These policies are required to meet 13 planning goals initially established by the Legislature. A recent amendment to the Act added the goals of the Shoreline Management Act as the 14th goal of the GMA. The Comprehensive Plan must contain plans and policies relating to the following 8 elements: land use; housing; capital facilities plan; utilities; rural element; transportation element; economic development; parks and recreation. Optional elements include conservation, solar energy, recreation, and subarea plans.

\(^6\)There are many other specific requirements of the GMA that are not highlighted here. For additional details, see Chapter 36.70A RCW and the decisions of the three Growth Management Hearings Boards at www.gmhb.wa.gov.

\(^6\)Recent court decisions have interpreted the GMA critical areas requirement to mean that the level of protection required to be met is a “no net loss of existing habitat functions and values” standard. However, the law does not require restoration. As yet, no jurisdictions in Washington apply their critical areas regulations from an ecosystem approach. They are mainly used to protect the functions and values found on specific sites.
### Appendix P1-2: Incentive Programs


<table>
<thead>
<tr>
<th>Program Name</th>
<th>Lead Agency</th>
<th>Incentive Type</th>
<th>Geographic Scope</th>
<th>Sector (Land Use)</th>
<th>Species Focus</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Salmon Fund</td>
<td>NFWF</td>
<td>Financial Assistance</td>
<td>WA</td>
<td>Ag, Timber, Suburban, Business, etc.</td>
<td>Salmon</td>
<td><a href="http://www.nfwf.org/programs/csf.htm">http://www.nfwf.org/programs/csf.htm</a></td>
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<tr>
<td>Conservation Reserve Enhancement Program (CREP)</td>
<td>FSA; WSCC (Farm Bill)</td>
<td>Financial Assistance</td>
<td>National</td>
<td>Ag</td>
<td>Salmon</td>
<td><a href="http://www.fsa.usda.gov/dafp/cepd/crp_statistics.htm">http://www.fsa.usda.gov/dafp/cepd/crp_statistics.htm</a></td>
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<td>Conservation Reserve Program (CRP)</td>
<td>FSA (Farm Bill)</td>
<td>Financial Assistance</td>
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<td><a href="http://www.fsa.usda.gov/dafp/cepd/crp_statistics.htm">http://www.fsa.usda.gov/dafp/cepd/crp_statistics.htm</a></td>
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<td>Farm and Ranch Lands Protection Program</td>
<td>NRCS</td>
<td>Financial Assistance</td>
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<td>Ag</td>
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<td><a href="http://www.nrcs.usda.gov/programs/frpp">http://www.nrcs.usda.gov/programs/frpp</a></td>
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<td>Forest Legacy Program</td>
<td>USFS (Farm Bill) DNR</td>
<td>Financial Assistance</td>
<td>National (2 WA projects FY 2006)</td>
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<td>Multiple</td>
<td><a href="http://www.dnr.wa.gov/htdos/amp/forest_legacy/legacyhome.html">http://www.dnr.wa.gov/htdos/amp/forest_legacy/legacyhome.html</a></td>
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<td>Program Name</td>
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<td>Geographic Scope</td>
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<td>Species Focus</td>
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<td>Forest Riparian Easement Program</td>
<td>DNR SFLO</td>
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<td>WA</td>
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<td><a href="http://www.dnr.wa.gov/sflo/frep">www.dnr.wa.gov/sflo/frep</a></td>
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<td>HCP Assistance Grants</td>
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<td>Financial Assistance</td>
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<td>HCP Land Acquisition</td>
<td>WDFW USFWS</td>
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<td>National</td>
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<td>Migratory Waterfowl Artwork Program</td>
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<td>Recovery Land Acquisition</td>
<td>WDFW USFWS</td>
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<td>National</td>
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<td>Regional Fisheries Enhancement Groups</td>
<td>WDFW</td>
<td>Financial Assistance</td>
<td></td>
<td>Various</td>
<td>Salmon</td>
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<td>Species Focus</td>
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<td>Rocky Mountain Elk Foundation Grants</td>
<td>RMEF (Private)</td>
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<td>Regional</td>
<td>Timber</td>
<td>Elk</td>
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<td>Rural Business Cooperative Service</td>
<td>USDA</td>
<td>Financial Assistance</td>
<td>National</td>
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<td>SRF Board IAC</td>
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<td><a href="http://www.iac.wa.gov/">http://www.iac.wa.gov/</a></td>
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<td>Wildlife Forever Grants</td>
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<td>Program Name</td>
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<td>Species Focus</td>
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<td>USDA Western Region</td>
<td>Financial Assistance, Research, Education</td>
<td>National</td>
<td>Ag</td>
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<td>Chehalis Fisheries Restoration Program</td>
<td>USFWS</td>
<td>Financial Assistance; Technical Assist.</td>
<td>WA (Chehalis River Basin, including Grays Harbor and tributaries)</td>
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<td>Family Forest Fish Passage Program</td>
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<td>Fish</td>
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<td>National Wetland Refuge Challenge Cost Share</td>
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<td>Program Name</td>
<td>Lead Agency</td>
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<td>Volunteer Cooperative Fish&amp; Wildlife Enhancement Prog.</td>
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<td>Forest Land Enhancement (FLEP)</td>
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<td>Financial Assistance; Technical Assist.; Educational Assistance</td>
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<td>Timber</td>
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<td>Program Name</td>
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<td>Environmental Quality Incentives Program</td>
<td>NRCS (Farm Bill)</td>
<td>Financial Assistance; Technical Assist; Educational Assist</td>
<td>National</td>
<td>Ag</td>
<td>Multiple</td>
<td><a href="http://www.nrcs.usda.gov/programs/equip">http://www.nrcs.usda.gov/programs/equip</a></td>
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<tr>
<td>Current Use Taxation/Public Benefit Rating System (PBRS)</td>
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<td>Property Tax Reduction</td>
<td>Counties (Chelan, King, Pierce, Clark Thurston - others?)</td>
<td>Various – Conservation emphasis set at local level.</td>
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<tr>
<td>Development Rights (Transfer or Purchase)</td>
<td>Local Gov't.</td>
<td>Legal/Statutory</td>
<td>Local option (King, Snohomish, Thurston, Whatcom -others?)</td>
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<td>Habitat Conservation Plan (HCP)</td>
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<td>Legal/Statutory</td>
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<td><a href="http://www.treefarmsystem.org/cms/pages/69_1.html">http://www.treefarmsystem.org/cms/pages/69_1.html</a></td>
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<td>Envirostars</td>
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<td>Program Name</td>
<td>Lead Agency</td>
<td>Incentive Type</td>
<td>Geographic Scope</td>
<td>Sector (Land Use)</td>
<td>Species Focus</td>
<td>Website</td>
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<td>Market Incentives</td>
<td>WA</td>
<td>Ag</td>
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<td><a href="http://dnr.metrokc.gov/wlr/farms/">http://dnr.metrokc.gov/wlr/farms/</a></td>
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<tr>
<td>Salmon Safe</td>
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<td>Market Incentives</td>
<td>WA and OR</td>
<td>Ag; Urban; Natural Area, Campus</td>
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<td><a href="http://www.salmonsafe.org">www.salmonsafe.org</a></td>
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<tr>
<td>Smart Wood</td>
<td>Rainforest Alliance</td>
<td>Market Incentives</td>
<td>National?</td>
<td>Timber</td>
<td>Multiple</td>
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<td>Earth Heroes</td>
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<td>Recognition</td>
<td>WA</td>
<td>Urban</td>
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<td><a href="http://www.metrokc.gov/earthlegacy/">http://www.metrokc.gov/earthlegacy/</a></td>
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<tr>
<td>Farming and the Environment Vim Wright Award</td>
<td>Farming and the Environment</td>
<td>Recognition</td>
<td>WA</td>
<td>Ag</td>
<td>Multiple</td>
<td><a href="http://www.farmingandthenvironment.org/">http://www.farmingandthenvironment.org/</a></td>
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<td>WA Natural Heritage Register</td>
<td>WDNR</td>
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<td>WA</td>
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<td>WA</td>
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<td>Program Name</td>
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<td>Incentive Type</td>
<td>Geographic Scope</td>
<td>Sector (Land Use)</td>
<td>Species Focus</td>
<td>Website</td>
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<td>Conservation Districts</td>
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<td>Technical Assistance</td>
<td>National</td>
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<td>Technical Assistance</td>
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<td>Ag</td>
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<td><a href="http://www.wa.nrcs.usda.gov/">http://www.wa.nrcs.usda.gov/</a></td>
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<td>Ecotrust</td>
<td>NGO</td>
<td>Technical Assistance</td>
<td>National</td>
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<td><a href="http://www.ecotrust.org/forestry/">http://www.ecotrust.org/forestry/</a></td>
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<td>Infrastructure DATABASE</td>
<td>WA State</td>
<td>Technical Assistance</td>
<td>WA</td>
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<td>Multiple</td>
<td><a href="http://www.infrafunding.wa.gov/ContactInformation.htm">http://www.infrafunding.wa.gov/ContactInformation.htm</a></td>
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<td>USFWS</td>
<td>Technical Assistance</td>
<td>National</td>
<td>Timber</td>
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<td>Land Trust Alliance (local land trusts)</td>
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<td>Seattle to Cascades</td>
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<td>Program Name</td>
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<td>Incentive Type</td>
<td>Geographic Scope</td>
<td>Sector (Land Use)</td>
<td>Species Focus</td>
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<td>Technical Assistance</td>
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<td>WA</td>
<td>Timber</td>
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<td><a href="http://www.nnrg.org/">http://www.nnrg.org/</a></td>
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<td>Pacific Forest Trust Conservation Easements and Land Trusts</td>
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<td>Technical Assistance</td>
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<td><a href="http://www.pacificforest.org">www.pacificforest.org</a></td>
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<td>Resource Conservation &amp; Development Program</td>
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<td>WA DNR</td>
<td>Technical Assistance</td>
<td>WA</td>
<td>Timber</td>
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<td><a href="http://www.dnr.wa.gov/sflo/">http://www.dnr.wa.gov/sflo/</a></td>
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<td>Small Farms Team</td>
<td>WSU Coop Extension</td>
<td>Technical Assistance</td>
<td>WA</td>
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<td>Stewardship Partners</td>
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<td>Ag, Timber, Sustainable Building</td>
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<td>Stewardship Planning Programs</td>
<td>King County</td>
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<td>Multiple</td>
<td><a href="http://dnr.metrokc.gov/wlr/cao">http://dnr.metrokc.gov/wlr/cao</a></td>
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<td>Program Name</td>
<td>Lead Agency</td>
<td>Incentive Type</td>
<td>Geographic Scope</td>
<td>Sector (Land Use)</td>
<td>Species Focus</td>
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<td>Technical Assistance</td>
<td>National</td>
<td>Various</td>
<td>Multiple</td>
<td><a href="http://www.tpl.org">http://www.tpl.org</a></td>
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<td>Technical Assistance</td>
<td>WA</td>
<td>Timber</td>
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<td><a href="http://ext.wsu.edu/kudos/">http://ext.wsu.edu/kudos/</a></td>
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<td>Center for Sustaining Agriculture &amp; Natural Resources (CSANR)</td>
<td>WSU Coop Extension</td>
<td>Technical Assistance, Research, Education</td>
<td>WA</td>
<td>Ag (including urbanizing areas)</td>
<td>Multiple</td>
<td><a href="http://csanr.wsu.edu">http://csanr.wsu.edu</a></td>
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</table>
As mentioned in Response to Question P1, the success of regulations or incentive programs in achieving habitat protection is largely unknown and dependent on strong monitoring and adaptive management programs. Few regulatory programs explicitly require monitoring of effectiveness or environmental outcomes. But, there are strong examples of such programs that are being used elsewhere that should be considered by the Partnership.

One example of such an adaptive management program is the Driver-Pressure-State-Impact-Response (DPSIR)\textsuperscript{63} approach used by European countries to assess management strategies in marine systems. This approach combines socioeconomic analysis with spatial analysis of pollutant transport and impact on the catchment-coastal zone system. Id. (The DPSIR framework permits the identification of the impact of socioeconomic development on the qualitative state of both marine and superficial waters.)

Monitoring and adaptive management programs are sparse in Puget Sound. Although good examples of programs do exist (e.g., PSNERP’s monitoring program, the former PSAT water quality monitoring program, and some stormwater monitoring under NPDES permits), there are few regulatory programs that require their use. This is an area where a significant gap exists in management tools in Puget Sound. As discussed in Response to Question S2, little is known about the effectiveness of our habitat/land use management tools (either regulatory or voluntary). Although a few Growth Boards decisions recently held that local regulations to protect critical areas must include a monitoring and adaptive management framework, this requirement is not a statutory requirement and not all jurisdictions include such programs. For those that do intend to include such monitoring and adaptive management programs, the work in many places is just beginning.

The monitoring and adaptive management plan must be able to produce information that enables these decision-makers to track the progress of health in Puget Sound at multiple scales (e.g., regional, action area, catchment, drift cell or by jurisdiction) and over relevant time frames. To get there, the monitoring and adaptive management plan must include basic descriptive monitoring:

- Setting goals and tracking implementation of strategies and actions;
- Tracking status and trends of key marine, freshwater and terrestrial species, watershed conditions (or conditions at a catchment or drift cell scale) and the major human threat factors, as well as natural factors (food web, disease, ocean and climate conditions);
- Determining the effectiveness of strategies and actions; and
- Validating hypotheses (which tell us whether the implemented actions caused the resulting ecosystem change and/or biological change in key species).

Appendix P2-1: A Discussion about Sustainable Living: What is the “Carrying Capacity” of Puget Sound – for people, for the ecosystem, and for the economy?

At Policy Recommendation No. 2 in the Response to Question P2, we recommend that the PSP begin a community conversation about what the future holds for a healthy Puget Sound over the next 50 years, as we face staggering population growth projections. In order to achieve a healthy Puget Sound, we believe that this includes three inextricably linked parts: healthy people, a healthy ecosystem and a healthy economy.

The Quality of Life Topic Forum and Public Health Forum are discussing two of these components: how we define our “quality of life” in terms of physical and emotional or spiritual health for people living in Puget Sound, as well as the elements of a healthy economy. The Land Use/Habitat Protection and Restoration Topic Forum intends to contribute to this discussion by framing the question about what it means to have a healthy ecosystem. To do this, we asked our scientists a simple, yet scientifically complex, question in layman’s terms: How much stress can the Puget Sound ecosystem tolerate before it breaks down? What follows is an insightful response which we hope contributes to this community conversation.

Q. How much stress can the Puget Sound ecosystem tolerate before it breaks down?

A. This question is stated a bit differently in the ecological literature, something like “At what point does the ecosystem assume another state?” The theory of stable ecosystem states is summarized in Gunderson, 2000. It basically says that if you push a system hard enough it will shift to another state that is somewhat stable (i.e., resistant to change). By “state” we mean the quantitative and qualitative description of species types, the numbers of species, their abundances, the flow of energy, the support of resources, the functions, etc.

To move the system back up into the undegraded state takes “energy” which means money (and lots of it) when it comes to restoring an ecosystem. That’s why conservation/preservation of ecosystems is preferred because it takes less energy/money than restoring.

In terms of Puget Sound, the multiple stressors acting together (i.e., accumulate) result in a cumulative impact on the ecosystem and thus can alter its state. Once the cumulative impacts reach a certain point, the system shifts (degrades) to another state.

For Puget Sound, the system is stressed in various ways, but scientists don’t think that the system overall has shifted into another state. We could verify this with an analysis of data on a variety of indicators. However, certain parts of the system, like Commencement Bay, are in an altered state. To bring Commencement Bay back to its undegraded state would take a huge effort. In comparison, large portions of the straits and the San Juan Islands are in something approximating pre-disturbance states. So, at the least we have these contrasting end members (low stress/high function, vs. high stress/low function). What we don’t know is the shape of the curve between these two, and the amount and kind of stresses that cause the shift.

We are not nearly at a point where we can state accurately what level of stress (i.e., the threshold level), and what combinations of stressors, will move the entire Sound into an altered state. Major changes in fundamental controlling factors could do this, like what has happened in the Columbia River estuary. There, dams have significantly altered hydrodynamics, logging and land conversion in the watersheds, and levees and dikes have eliminated connections with vital floodplain wetland areas. The system has shifted from a marsh macrodetritus based food web to a plankton based food web with effects ramifying throughout the food web of the system.

Some researchers are trying to piece together information that shows a shift in the food web in Puget Sound, but that is not finished and probably won't be conclusive evidence. At this juncture we can point to loss of tidal habitats, degradation of existing habitats, alterations in fish communities, contamination in food webs, hypoxia events, loss of eelgrass in some areas, etc., as evidence that the system is stressed, and may be on the verge of shifting to a significantly altered system. However, what “on the verge” means is not known.

We need a comprehensive/credible study of the cumulative effects of multiple stressors on the ecosystem. Short of that, our scientists will need to rely on adding impacts up (i.e., use an additive model) and use more qualitative descriptors of the system state. An additive model is what we and others have applied to county shorelines (e.g., Jefferson County Nearshore Assessment) and watersheds (e.g., the Bellingham watershed study performed by Stephen Stanley et al.). Extending these additive model assessments consistently throughout Puget Sound would go a long way toward addressing this question.65

Appendix P2-2: An Illustration of Our Proposal to Create a New Restoration Standard

Existing No Net Loss Approach in Washington

No Net Loss – Current Baseline

- Project Impacts *
- On-Site Mitigation Of Impacts
- Non-Regulatory Restoration

No Net Loss of Ecological Function & Restoration

No Net Loss – Current Baseline

- Project Impacts *
- Restoration to offset cumulative impacts of allowed projects **
- Compensatory Restoration
- Mitigation for Project Impacts

Non-Regulatory Restoration Opportunities – Improving Function Over Time

- Ecosystem Based Restoration Plan
  - Non-Regulatory
  - Regulatory (required to achieve no net loss of ecological function)

Implementation Over Time

* This should include minimization of impacts through innovative planning measures such as clustering, transfer of development rights, site specific BMP’s, and other green infrastructure measures to minimize impacts to ecosystem processes and function.

** Replacement of ongoing loss of functions. Occurs as result of inefficiencies of mitigation design and implementation, reasonable use exemptions, minimum size exemptions, etc. This could include implementation of other measures in the restoration plan.
### Appendix P2-3: Protection and Restoration Strategies for Puget Sound Ecosystems

Examples of Project Types and Targeted Ecosystem Benefits (adapted from Johnson et al. 2003).

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Project Type</th>
<th>Targeted Ecosystem Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection</td>
<td>Land acquisition</td>
<td>Preserves existing intact ecological features, functions, and processes at site scale and/or enables the application of additional strategies without human land use constraints, but requires long-term management.</td>
</tr>
<tr>
<td></td>
<td>Land use regulations</td>
<td>Limits or prohibits potentially harmful land use activities on or adjacent to the land surrounding the site, thereby protecting habitat-forming processes and features.</td>
</tr>
<tr>
<td>Conservation</td>
<td>Land conservation</td>
<td>Limits land use impacts harmful to salmon habitat such as sediment, contaminants, nutrient loading.</td>
</tr>
<tr>
<td></td>
<td>Easements</td>
<td>Benefits ecological features through legal protection of critical areas, potentially allowing for complementary restoration strategies to take place.</td>
</tr>
<tr>
<td></td>
<td>Riparian fencing</td>
<td>Deters livestock from degrading stream-side areas.</td>
</tr>
<tr>
<td></td>
<td>Manure management</td>
<td>Minimizes the inputs of nutrients and bacteria into stream corridor.</td>
</tr>
<tr>
<td></td>
<td>Tide gate/culvert replacement</td>
<td>Promotes water temperature reduction, dissolved oxygen availability, increased habitat access.</td>
</tr>
<tr>
<td></td>
<td>Invasive species removal</td>
<td>Increases opportunities for native species propagation.</td>
</tr>
<tr>
<td></td>
<td>Riparian fencing</td>
<td>Protects riparian zones from disturbances.</td>
</tr>
<tr>
<td>Restoration</td>
<td>Tide gate removal</td>
<td>Restores partial or full hydrologic connection to slough habitat improving water quality, access to lost habitat types and processes, and potential removal of invasive plant species.</td>
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<tr>
<td></td>
<td>Dike breaching</td>
<td>Provides similar benefits as tide gate removal, this application requires significant earth moving activities to allow tidal energy to influence historic slough signatures and can involve tidal channel excavation.</td>
</tr>
<tr>
<td></td>
<td>Culvert upgrades/culvert installation</td>
<td>Provides similar benefits to above restoration activities through the improvement of water quality, access to lost habitat types and processes, and potential removal of invasive species.</td>
</tr>
<tr>
<td></td>
<td>Elevation adjustment</td>
<td>Restores elevation of site to level that will support appropriate wetland vegetation.</td>
</tr>
<tr>
<td>Creation</td>
<td>Material placement</td>
<td>Mimics habitat function and complexity through the placement of material at a given elevation.</td>
</tr>
<tr>
<td></td>
<td>Tidal channel modification</td>
<td>Restores more natural flows and mimics tidal channel structure.</td>
</tr>
</tbody>
</table>

NOTE: Due to its large size, this document is available through the website at http://www.oceancommission.gov
Plastic Geoduck Seed Tubs
Harstine Island, 2008

Statistics:
> 1,000 pools
> 28,000 sq ft of plastic on inter-tidal beach
No permit applied for

Inter-tidal Activity
"Kiddie" pools
Tractor

Pocket Estuary