

Marine Spatial Planning in Washington: A Spatial and Temporal Assessment of Current Uses
and Potential Conflicts

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Abstract

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As humanity's capacity for developing new ways to extract and use resources proliferates, so does its use of ocean space and demand for ocean resources by an ever-growing pool of users. Anticipating disputes from this growth, Washington State initiated the process of Marine Spatial Planning (MSP) to protect existing uses by minimizing conflicts between current and future uses – most notably renewable energy – along Washington's coastline. As part of this process, Washington State is currently assessing conflicts between existing and future marine uses, yet no baseline study has assessed the intensity of the current level of spatial and temporal use conflict between current marine users. This paper uses spatial, temporal, and use-intensity data for 27 major marine uses to quantify potential conflict and highlight high- and low-intensity areas within Washington's MSP study area. A novel Marine Conflict Index (MCI), calculated by combining the degree of spatial and temporal overlap between pairs of uses and accounting for their intensities, is used to evaluate pairwise potential conflicts between uses. The spatial extent of uses varies widely throughout the designated MSP study area. 38 pairs of uses, about 10% of

the total, did not overlap spatially and therefore are likely compatible with one another.

Temporally the number of uses peaks in July and August and falls to a low during January and February. The MCI identified three important user groups with a substantial degree of potential conflict: commercial fishing with commercial fishing, commercial fishing with Tribal usual and accustomed fishing areas, and commercial fishing with shipping. A cumulative intensity analysis found that medium- to high-intensity use characterized much of the MSP study area, whereas low-intensity use characterized Grays Harbor, Willapa Bay, and the Northwestern corner of the MSP study area. By ground truthing results with external evidence of actual conflict, three cases highlight how MCI scores can represent potential conflict to understand compatibilities and actual conflict for marine managers. This report is the first representative use analysis on Washington's existing marine uses that includes spatial, temporal, and intensity factors, providing a crucial first look at ongoing and potential conflicts between marine uses. These results are intended to inform the Washington MSP process to meet one of its core goals of protecting and preserving existing uses while planning for future uses. Beyond Washington, this study provides a template for examining potential use conflicts that incorporates space, time, and intensity and is applicable for any marine planning process.

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1. Introduction

Human dependence on current marine uses, such as fishing and shipping, continues to increase while emerging enterprises, most notably renewable energy, create new demands for marine resources (Douvere, 2008; Van Cleve et al., 2013; Kannen, 2012; White et al., 2012). With a proliferation of marine activities comes the potential for an intensification of conflicts between activities competing for the same limited resources and space within the marine environment (Crowder et al., 2006; Douvere, 2008; Cicin-Sain, Knecht, Jang, and Fisk, 1998). Those who manage the ocean and its vast assets employ several different forms of management, primarily those that deal with individual sector management (Crowder et al., 2006; Halpern et al., 2008). However, the rise of conflicts between current activities and the potential for future conflicts with new uses creates a need for a more inclusive and preemptive management tool that allows managers to plan for more than one sector and anticipate future scenarios (Crowder et al., 2006; White et al., 2012).

President Obama's 2010 Executive Order 13547 and the 2010 Interagency Ocean Policy Task Force's Final Report (Ocean Policy Task Force, 2010) establish a platform for the United States to improve upon current ocean policies and management regimes by implementing marine spatial planning (MSP). The MSP process "is designed to decrease user conflict, improve planning and regulatory efficiencies, decrease associated costs and delays, engage affected communities and stakeholders, and preserve critical ecosystem functions and services" (Ocean Policy Task Force, 2010). MSP is a tool to balance the use of an area by managing demand for ocean space through social, ecological, and economic factors in a coordinated and comprehensive plan and development framework (Ocean Policy Task Force, 2010; "Washington

Marine Spatial Planning: News,” 2015). While the federal government plans to use regional bodies to carry out MSP throughout the U.S., efforts have been lagging (Olsen et al., 2014). During this time several States including Massachusetts, Rhode Island (McCann et al., 2010), California, Oregon, and Florida have already used a MSP process to help improve management and mitigate ocean conflicts (NOAA Office for Coastal Management, 2014). In practice, State development of spatial plans will likely lead to engagement in broader regional efforts and the incorporation of information and management objectives when the timing is considered appropriate (National Ocean Council, 2013).

Washington State is developing a marine spatial plan for its coastal and marine waters with goals such as maintaining a healthy marine ecosystem capable of supporting sustainable uses (“Washington’s Pacific Coast Final MSP Actions List,” 2014) and improving coordination of marine management among all levels of government (*Marine Waters Planning and Management Act*, 2010). Washington has defined MSP as “a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives” (*Marine Waters Planning and Management Act*, 2010). The Marine Waters Planning and Management Act (2010) dictates guidelines for developing MSP and content that must be included in the plan. This Act also states that the finalized marine spatial plan must be submitted to the National Oceanic and Atmospheric Administration (NOAA) for approval (*Marine Waters Planning and Management Act*, 2010). Once approved by NOAA, the plan can be added into Washington’s federally approved coastal zone management program (*Marine Waters Planning and Management Act*, 2010; Hennessey & State Ocean Caucus, 2011). One main objective of MSP in Washington is to protect and preserve existing uses by planning for new uses and the potential conflicts that may arise (*Marine Waters*

Planning and Management Act, 2010). These new uses include marine renewable energy, marine mining, off-shore aquaculture, new areas for dredge material disposal, and marine bio-extraction (“Washington Marine Spatial Planning: News,” 2015). A big driver behind MSP in Washington is the uncertain potential for marine renewable energy and inadequacies in the States’ framework for anticipating and managing new uses while protecting existing uses (“Washington Marine Spatial Planning: News,” 2015). MSP must specifically consider renewable energy as entailed in the Washington Marine Waters Planning and Management Act (2010). The emerging technology for marine renewable energy created impetus to consider where such uses might be located off the coast of Washington through analyzing the physics of the marine environment and technology to capture it (Van Cleve et al., 2013; White et al., 2012). Additionally, the natural wind and wave resources make Washington’s waters largely suitable to generate significant power. Understanding the potential for marine renewable energy allows appropriate locations to be cited and inform future actions (*Marine Waters Planning and Management Act*, 2010; DOE, 2011). However, the suitable areas are heavily utilized by current activities and require careful planning for any new development (Van Cleve et al., 2013). If Washington wants to protect existing uses and manage the impact of new uses along the coastline, especially waters outside of state jurisdiction, the marine spatial plan must identify important areas for current uses and highlight areas to develop future uses with minimal conflict.

Washington’s marine spatial plan encompasses the marine area confined by a landward boundary of the Washington coastline, including both Willapa Bay and Grays Harbor, and a seaward boundary extending out to the 700-fathom contour of the ocean floor (Washington Department of Ecology, 2014, p. 8). This boundary was designated because new uses are technically feasible in this area, activities within this area can impact the coast, it encompasses

major areas of human activities, it has ecological significance (e.g., upwelling occurs here, there are important habitats, and the ecological processes throughout are connected to the nearshore environment), and this area is data rich (Washington Department of Ecology, 2014). State agencies, led by the Washington Department of Ecology (WDOE), are working together to compile ocean data and spatial information for incorporation into a completed marine management plan (*Marine Waters Planning and Management Act*, 2010). Additionally, the planning process is intergovernmental by inviting federal and local agencies and tribal governments to provide input throughout the process. Stakeholders are also included through a coordinated MSP stakeholder group, the Washington Coastal Marine Advisory Council, as well as through input from each coastal county Marine Resources Committee and the general public. Specifically, coordination must occur with tribal governments and their rights along the coast must be recognized (*Marine Waters Planning and Management Act*, 2010). Treaties between the coastal Tribes as sovereign nations and the United States guarantee these rights, which include the rights to their usual and accustomed fishing areas and the opportunity to catch 50% of the allocated fish within these areas (*United States v. Washington*, 1974).

MSP commonly includes steps such as establishing authority, including stakeholders, defining and analyzing existing and future marine uses, and making the plan adaptive (Ehler and Douvère, 2009; Ocean Policy Task Force, 2010; *Marine Waters Planning and Management Act*, 2010). A logical starting point for the MSP process is to analyze existing uses and current conditions. For example, one guide for developing MSP states that a plan for future conditions must define and analyze existing conditions, acknowledging the importance of conducting an analysis of current conflicts and compatibilities between uses to help inform planning (Ehler and Douvère, 2009). With Washington State planning for future uses through MSP, baseline

conditions and baseline assessments have been completed with Washington currently completing a Use Analysis (“WCMAC Discussion Guide - Use Analysis Process,” 2015). While these are important steps, the last synthesis and analysis of existing coastal uses was completed in 1989 (Strickland and Chasan, 1989), and since then there has been no compatibility study and assessment or analysis of existing conflicts between important marine uses. In addition, the Washington Marine Waters Planning and Management Act (2010) details that “the marine management plan must [recognize] and [respect] existing uses.” An assessment of potential conflict between current marine uses is not only a step that cannot be overlooked as Washington develops a marine management plan, but is also in line with State requirements for MSP to consider and protect existing uses.

While Washington State intends MSP to decrease future marine conflicts, the state process does not include an analysis of the conflict among current important marine uses. This study aids the MSP process in Washington by doing just such an analysis of use conflicts within the Washington MSP study area.

The first step of the present study was to map current uses as listed in the Washington MSP data catalog (“Washington Marine Spatial Planning: Data Catalog,” 2015). A spatial, temporal, and use intensity analysis indicates the potential degree of conflict between each set of current uses. Additionally, an overall analysis within the MSP study area measures the overall use intensity to find areas within coastal and marine waters that have the highest- and lowest-use intensity. This analysis differs from Washington’s Use Analysis in both its timeline and focus. The WA Use Analysis is listed for completion by December of 2015 and focuses on potential new uses (“WCMAC Discussion Guide - Use Analysis Process,” 2015), whereas the present

study analyzes the potential conflict between current uses, an important and logical next step in the MSP process.

The approaches employed here use overlaps in space and time to identify areas where uses may potentially conflict providing a first spatial assessment of current uses and use intensities (see Box 1 for definitions). Because this treats overlaps in space and/or time as potential areas of conflict, it does not imply that all overlaps constitute conflict. For example, there are compatible uses within overlapping space that have accommodated each other in practice through agreements or governmental regulations. To fully document conflict, it is necessary to have data on actual interactions. The intent of this study is to develop and employ a spatial and temporal analysis comparing extent of use, time of use, and the intensity of use in pairwise overlaps and the extent of use and intensity of use through cumulative analyses. This analysis provides a critical underpinning for MSP in Washington by highlighting potential conflicts and compatibilities in both space and time that are necessary considerations for spatial management. In a larger context, this study follows best management practices according to Elher and Douvere (2009) and offers a method for quantitatively assessing use conflicts applicable to processes beyond MSP.

Box 1.

Definitions:

Marine use – the act or practice of employing resources or space through measures such as exploitation, recreation, or conservation or through use of space (e.g., whale and dolphin migrations) (modified from Merriam-Webster, 2015).

Potential conflict – overlap in space and/or time, with the possibility of resulting incompatibilities or compatibilities among users.

Conflict – specifically refers to incompatibilities among users over the use of particular ocean resources or space (Cicin-Sain, 2003).

2. Methods

To assess the spatial extent, temporal extent, intensity of use, and potential conflict between a host of representative marine uses in Washington, GIS data layers (datasets) were collected and analyzed with ArcGIS 10.2.2 software (ESRI, USA).

2.1. Data collection

The majority of the data used in this study derive from the State's MSP data catalog ("Washington Marine Spatial Planning: Data Catalog," 2015). All datasets were from various sources such as the WDOE, Washington Department of Fish and Wildlife (WDFW), Washington Department of Natural Resources (WDNR), and NOAA (Table 1). While the catalog hosts a large amount of empirical data previously collected from state agencies, datasets were only included if they occurred in marine waters (rather than onshore) and if they could be converted into polygons applicable for analyses (rather than point data). A total of 10 empirical datasets from the catalog met these criteria at the time of the study and were selected for the analysis. Additionally, other empirical datasets were included that WDNR recommended adding to the analysis and were either updated versions of data in the catalog at the time of the study (e.g., 2013 shipping densities) or were added as they became publically available throughout the analysis (e.g., Ocean Dredge Disposal).

To have a wide variety of datasets for realistic representation of all marine uses, five environmental datasets that occur within specific areas (e.g., Olympic Coast National Marine Sanctuary) or that varied in intensity across space (e.g., whale densities) were included (Table 1). These consist of Southern Resident Killer Whales (SRKW) (all datasets hereafter will be

capitalized for clarification), included because they are listed under the Endangered Species Act; Olympic Coast National Marine Sanctuary (OCNMS), included because it creates restrictions on uses within the area; Essential Fish Habitat (EFH), included because it designates areas that are environmentally important for fish species; and Pacific White Sided Dolphins and Humpback Whales, both included because they had the large variation in use-intensity across space and they are common marine species in the Pacific Northwest.

Table 1. Source of GIS datasets included in the analysis.

Datasets	Data Source
MSP Boundary Polygon	Mikaela Freeman - combined layers from WDOE and WDNR
Commercial Fishing - Coastal Crab (Dungeness)	WDFW
Commercial Fishing - Pink Shrimp	WDFW
Commercial Fishing - Sardine	WDFW
Commercial Fishing - Bottom Trawl (Groundfish)	WDFW
Commercial Fishing - Mid-water Trawl (Pacific Whiting)	WDFW
Commercial Fishing - Albacore	WDFW
Tribal Usual & Accustomed Fishing Areas (U&As)	Mikaela Freeman - as specified by 50 CFR 660.50
Recreational Fishing - Albacore	WDFW
Recreational Fishing - Bottomfish	WDFW
Recreational Fishing - Halibut	WDFW
Recreational Fishing - Salmon	WDFW
Commercial Intertidal Harvest	Participatory mapping workshop - NOAA & BOEM
Recreational Intertidal Harvest	Participatory mapping workshop - NOAA & BOEM
Ocean Dredge Disposal	Combined layers - WDNR & Army Corps
Military Practice Areas	Mikaela Freeman - combined layers from NOAA Electronic Navigation Charts & NOAA Raster Nautical Charts and participatory mapping workshop - NOAA & BOEM
Shipping Densities - Cargo	NOAA Olympic Coast National Marine Sanctuary
Shipping Densities - Fishing	NOAA Olympic Coast National Marine Sanctuary
Shipping Densities - Passenger	NOAA Olympic Coast National Marine Sanctuary
Shipping Densities - Tugs	NOAA Olympic Coast National Marine Sanctuary
Shipping Densities - Tankers	NOAA Olympic Coast National Marine Sanctuary
Shipping Densities - Miscellaneous	NOAA Olympic Coast National Marine Sanctuary
Wind Power Suitability	U.S. Department of Energy's National Renewable Energy Laboratory
Essential Fish Habitat Conservation Areas (EFH)	NOAA NMFS Habitat Conservation
Southern Resident Killer Whales (SRKW)	NOAA Fisheries, Northwest Region, Protected Resources Division, Portland, OR
Pacific White Sided Dolphins	Southwest Fisheries Science Center
Humpback Whales	Southwest Fisheries Science Center
Olympic Coast National Marine Sanctuary (OCNMS)	NOAA Olympic Coast National Marine Sanctuary

In addition to these empirical datasets, the MSP data catalog includes a suite of data from a public participatory mapping workshop conducted by NOAA and the Bureau of Ocean Energy Management (BOEM and NOAA, 2013; hereafter “participatory data or datasets”). This workshop brought together stakeholders and community experts from Washington to compile knowledge and interactively map uses along the coast (BOEM and NOAA, 2013). While the focus for data collection in the present study was on empirical data, a few of the participatory

datasets were used in place of or were added to the empirical datasets. This occurred when it was clear that participatory data were more specific representations of a marine use (e.g., intertidal harvest datasets) or allowed for adding intensity values (e.g., Military Practice Area).

Two additional datasets were included, neither of which come from empirical or participatory data, due to their importance both along the Washington coast and for consideration in the MSP process. One dataset was the tribal usual and accustomed fishing areas (Tribal U&As). This dataset was included following specifications from the Code of Federal Registrar that details the locations of U&As for the Pacific Coast Treaty Tribes (*Pacific Coast Treaty Indian Fisheries*, 2012). The other dataset included was a Wind Power Suitability dataset (Van Cleve et al., 2013) and was the only future use included in this study. Renewable energy was chosen over the other four new uses since it is a driver for MSP (see Section 1) and due to availability of marine renewable energy suitability data. Wind power specifically was chosen over the other two marine renewable energy types assessed for Washington due to availability of the data. (For descriptions, a MSP study area map, and individual dataset maps see Appendix A)

2.2. ArcGIS format

All data were loaded into ArcGIS using the High Accuracy Reference Network (HARN) upgrade of the North American Datum of 1983 and a Lambert Conformal Conical projection of the Washington South State Plane coordinate system¹. Data were then clipped, or restricted, to the MSP study area using the Washington MSP Boundary layer (MSP study area). All data were

¹ The projection used was: NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet projection* (a Lambert Conformal Conical projection). NAD 83 is “the horizontal control datum for the United States, Canada, Mexico, and Central America, based on a geocentric origin and the Geodetic Reference System 1980...[and] is the current geodetic reference system” (NOAA National Geodetic Survey, 2015). HARN is “a statewide or regional upgrade in accuracy of NAD 83 coordinates using Global Positioning System (GPS) observations” (NOAA National Geodetic Survey, 2015).

Since the majority of data gathered at the start of the analysis were fishing data from Washington Department of Fish and Wildlife and was already projected in the NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet projection, all other ArcGIS layers were changed to the same projection.

in vector format (aside from shipping datasets which were provided in raster format) for the initial matrix and changed into raster format for overall analyses.

2.3. Analysis methods

Two analyses characterized the interactions among uses in Washington waters: a novel marine conflict index (MCI) – which combines a pairwise area of overlap matrix, a pairwise month-by-month overlap matrix, and a pairwise use intensity matrix to generate minimum and maximum conflict scores – and an assessment of cumulative use intensity.

2.4. MCI

Spatial Overlap:

To assess the area of overlap between all pairs of marine uses, the spatial intersection of each pair was calculated using an ArcGIS model and the units of all intersecting areas were converted from ft² to km² to create a spatial matrix (see Appendix B).

Temporal Overlap:

Uses were scored for a simplified measure of temporal duration by noting the presence and absence of each use in each of the twelve calendar months. While details of these uses may vary between years (e.g., exact fishing seasons may change each year or uses may take place sporadically, but for only several days out of the year), for simplicity and due to data limitations these details were broadened and simplified here. The result was a binary matrix, in which each use either takes place within a calendar month or it does not. A matrix of temporal overlap

between pairs of uses (in number of months of overlap) was subsequently derived from this same data (see Appendix B).

Intensities:

Datasets for uses such as all commercial and recreational fishing, all shipping, Commercial and Recreational Intertidal Harvests, Pacific White Sided Dolphins, Humpback Whales, and Wind Power Suitability showed varying use, which were previously assigned by the original source as attributes within each datasets. For the present analysis these attributes were changed to discrete numerical values on a one to five scale to show use intensity. Datasets that did not vary in use, such as Ocean Dredge Disposal and Tribal U&As, were given the highest intensity based on the assumption that these were high use areas because these uses have the potential to occur whenever and wherever within these specific areas. This one to five scale was employed to create two pairwise matrices of use intensity. Minimum and maximum intensity values for each datasets were used to create a minimum intensity pairwise matrix and a maximum pairwise matrix, respectively. To get minimum and maximum intensity values each use was represented by either its highest or lowest intensity value for its entire spatial extent. To assign values for the pairwise minimum intensity matrix, the lowest intensity values of each use were multiplied to represent overall intensity. The same was done for the pairwise maximum intensity matrix using the highest intensity values.

Calculating MCI:

The conflict index for a pair of uses was the product of their spatial overlap (in km²), temporal overlap (in months), and the minimum or maximum intensity of each use (1-5 scale). That is, $MCI = \text{spatial overlap} * \text{temporal overlap} * \text{intensity}$. Both a minimum conflict index

(MCI_{min}) and a maximum conflict index (MCI_{max}) were created from these results. Raw scores were then scaled by the maximum observed value within each MCI matrix to derive a zero to one scale (MCI scores) for existing use conflicts within the MSP study area.

MCI_{min} may misrepresent potential conflicts by overvaluing uses whose datasets did not have assigned intensity values (therefore assigned an intensity of five) yet also had large spatial areas (e.g., Tribal U&As, OCNMS, and Military Practice Areas). Therefore, the analysis focused specifically on MCI_{max} scores (herein referred to as MCI). Having generalized one intensity value for an entire dataset, MCI scores, which reflect highest intensity value for each dataset, represent a worst-case scenario for conflict between two given uses.

2.5. Cumulative spatial intensity analysis

To map cumulative use intensities for the entire MSP study area, vector data were converted into raster format (cell size = 1,000 feet) so that each dataset was comprised of a grid of cells with individual intensity values. The datasets were then overlaid to create a map of the sum of intensities within the MSP study area. Note this simple analysis treats all uses as having equivalent weight and the cumulative intensity of uses as being additive. Therefore, the cumulative use intensity for the study area consisted of the union of the spatial areas, scaled by intensity, for all existing uses (this did not include Wind Power Suitability as it is a future use). In addition to an overall map with all existing uses, several maps with groups of uses were used to identify areas of high-intensity for particular sectors. These maps were made using three categories, which naturally appeared within the 27 datasets: shipping (Cargo, Fishing, Passenger, Tugs, Tankers, and Miscellaneous), fishing (all commercial and recreational fishing datasets and Tribal U&As), and all others. Additionally, a map was also made with only environmental

datasets (EFH, OCNMS, SRKW, Humpback Whales, and Pacific White Sided Dolphins) to show environmentally important areas within the MSP study area. While a representative group of datasets was included, the present study it is not a comprehensive assessment of all uses and the spatial results produced by these methods are driven by the chosen datasets.

3. Results

3.1. Current Uses

General results

Of the 27 use datasets included in the analysis (Table 1), the ten largest spatial uses include five commercial fishing datasets (Albacore, Bottom Trawl, Mid-water Trawl, Sardine and Crab), Pacific White Sided Dolphins, Humpback Whales, Military Practice Areas, Recreational Salmon Fishing, and Tribal U&As (Table 2). The largest spatial use is Commercial Albacore at 20,365 km², which covers 99% of the entire MSP study area, although the intensity throughout this area varies. The five smallest uses are Ocean Dredge Disposal (22 km²), SRKW (73 km²), Shipping – Passenger (96 km²), Shipping – Tanks (317 km²), and Commercial Intertidal Harvest (513 km²).

Table 2. Top ten largest spatial uses.

	Datasets	Area (sq km)	% of Total Area
1	Commercial Albacore	20365	0.999
2	Pacific White Sided Dolphins	19677	0.965
	Humpback Whales	19677	0.965
4	Commercial Bottom Trawl	17715	0.869
5	Commercial Mid-water Trawl	17422	0.855
6	Tribal U&As	13540	0.664
7	Military Practice Areas	12545	0.615
8	Commercial Sardine	11255	0.553
9	Commercial Crab	11042	0.542
10	Recreational Salmon	11036	0.541

Temporally, 15 uses each take place during all 12 calendar months (Table 3). Conversely, the most temporally confined uses are Recreational Halibut fishing, which happens only in May (often the fishery is only open for a couple of days), and Pacific White Sided Dolphins and Humpback Whales, both of which are only along the Washington coast for the three summer months of the year. January and February have the lowest number of uses occurring, 15 out of the 27, while July and August have the highest number of uses with all uses, except for Recreational Halibut, occurring during these months.

Table 3. Descriptive temporal chart for all datasets.

Datasets	January	February	March	April	May	June	July	August	September	October	November	December	Total Months
Comm Crab	[Red bar]												10
Comm Pink Shrimp	[Red bar]												7
Comm Sardine	[Red bar]												9
Comm Bottom Trawl	[Red bar]												12
Comm Mid-water Trawl	[Red bar]												6
Comm Albacore	[Red bar]												5
Tribal U&As	[Dark Red bar]												12
Rec Albacore	[Light Blue bar]												5
Rec Bottomfish	[Light Blue bar]												7
Rec Halibut	[Dark Blue bar]												1
Rec Salmon	[Dark Blue bar]												5
Comm Intertidal Harvest	[Dark Blue bar]												12
Rec Intertidal Harvest	[Dark Blue bar]												12
Ocean Dredge Disposal	[Orange bar]												12
Military Practice Areas	[Orange bar]												12
All Shipping	[Orange bar]												12
Wind Power Suitability	[Orange bar]												12
EFH	[Light Green bar]												12
SRKW	[Light Green bar]												9
Pacific White Sided Dolphins	[Light Green bar]												3
Humpback Whales	[Light Green bar]												3
OCNMS	[Dark Green bar]												12

MCI results

The top 25 MCI potential conflicts (Table 4) include Commercial Bottom Trawl conflicts with Commercial Mid-water Trawl, Commercial Sardine, Commercial Crab, and Commercial Albacore (four out of the six total commercial fisheries). Additionally, the top 25 MCI potential conflicts show Tribal U&As may conflict with Commercial Fishing (Bottom Trawl and Mid-water Trawl) as well as with shipping (Fishing, Miscellaneous, and Tug vessels). Lastly, Commercial Bottom Trawl is the fishery that has high potential conflicts with shipping

(Miscellaneous, Cargo, and Tug vessels). When using MCI, the majority of the top 25 potential conflicts can be classified into three informative groups: commercial fishing with commercial fishing, commercial fishing with Tribal U&As, and commercial fishing with shipping. (See Appendix B for MCI min scores)

Table 4. Top 25 MCI scores of potential pairwise conflicts.

	MCI Max Score	Potential Pairwise Conflict
1	1.0000	Tribal U&As & Comm Bottom Trawl
2	0.9679	Tribal U&As & Military Practice Areas
3	0.8711	Comm Bottom Trawl & Military Practice Areas
4	0.8218	Comm Bottom Trawl & Shipping - Misc.
5	0.7263	Comm Bottom Trawl & Comm Mid-water Trawl
6	0.7197	Comm Bottom Trawl & Shipping - Cargo
7	0.7127	Comm Bottom Trawl & Shipping - Tug
8	0.7021	Comm Bottom Trawl & Comm Sardine
9	0.6874	Tribal U&As & OCNMS
10	0.6794	Tribal U&As & Shipping - Fishing
11	0.6313	Comm Bottom Trawl & Comm Crab
12	0.6160	Comm Bottom Trawl & Comm Albacore
13	0.6054	Comm Mid-water Trawl & Comm Albacore
14	0.5767	Shipping - Misc & Shipping - Fishing
15	0.5645	Tribal U&As & Shipping - Misc
16	0.5767	Shipping - Fishing & Shipping - Misc
17	0.5755	Comm Bottom Trawl & OCNMS
18	0.5709	OCNMS & Military Practice Areas
19	0.5645	Tribal U&As & Shipping - Misc
20	0.5627	Shipping - Fishing & Military Practice Areas
21	0.5067	Shipping - Misc & Shipping - Cargo
22	0.4999	Shipping - Fishing & Shipping - Tug
23	0.4959	Tribal U&As & Comm Mid-water Trawl
24	0.4807	Tribal U&As & Shipping - Tug
25	0.4697	Tribal U&As & Comm Albacore

In 38 pairs of uses, about 10% of the total number evaluated, there are no potential conflicts due to a lack of spatial and/or temporal overlap (Table 5). Recreational and Commercial Intertidal Harvest, Recreational Albacore, Recreational Halibut, SRKW, and Ocean Dredge Disposal are a few examples of the datasets that have multiple pairwise MCI scores of zero.

Table 5. Pairwise datasets with no potential conflict.

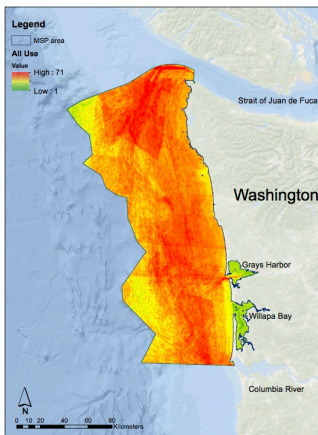
Datasets			Datasets		
1	Rec Intertidal Harvest	EFH	20	Rec Albacore	Ocean Dredge Disposal
2		Comm Pink Shrimp	21		Rec Halibut
3		Comm Sardine	22	Rec Halibut	SRKW
4		Comm Mid-water Trawl	23		Ocean Dredge Disposal
5		Comm Bottom Trawl	24		Comm Albacore
6		Rec Halibut	25		Comm Mid-water Trawl
7		Rec Albacore	26		Humpback Whales
8		Shipping - Passenger	27		Pacific White Sided Dolphins
9	Comm Intertidal Harvest	EFH	28	SRKW	EFH
10		SRKW	29		Tribal
11		Comm Pink Shrimp	30		Comm Mid-water Trawl
12		Comm Sardine	31		Comm Bottom Trawl
13		Comm Mid-water Trawl	32		Comm Sardine
14		Comm Bottom Trawl	33		Comm Crab
15		Rec Halibut	34		Comm Pink Shrimp
16		Rec Albacore	35		Rec Bottomfish
17	Shipping - Passenger	36	Ocean Dredge Disposal		
18	Rec Albacore	Wind Power Suitability	37	Ocean Dredge Disposal	EFH
19		SRKW	38		Comm Pink Shrimp

Cumulative intensity results

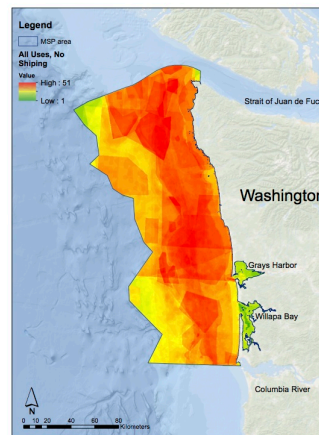
To illustrate cumulative intensity of marine uses within the MSP study area, a variety of intensity maps were prepared (Figure 1). Taking all 27 analyzed uses (Figure 1a), the northern portion of the study area has the highest use intensity, while Willapa Bay, Grays Harbor, and a small section in the Northwest corner of the study area have the lowest use intensity. When all uses except shipping are considered (Figure 1b), areas closest to the coast have the highest use, with the northern two-thirds of this area exhibiting exceptionally higher use. Mapping all uses except for fishing (Figure 1c) shows high-intensity use in the northern portion of the study area, driven mostly by shipping lanes, with very low-intensity use in both Willapa Bay and Grays Harbor. When both shipping and fishing are excluded and all other marine uses are considered (Figure 1d), both coastal waters and the northern two-thirds of the boundary have high-intensity use while the Southern one-third of the study area, especially waters outside of 3nm, have the lowest intensity use. When fishing is mapped independently (Figure 1e), the southern central portion of the study area has the highest use intensity with the lowest intensity occurring both in

Willapa Bay and Grays Harbor as well as small areas in both the Northwest and Northeast corners. When mapping only shipping (Figure 1f), there are distinct high-intensity use shipping lanes in the northern region of the map (at the mouth of the Strait of Juan de Fuca) as well as high-intensity use lanes coming from Grays Harbor and from the southern region of the map near the mouth of the Columbia River. Aside from these lanes, there is low- to medium-intensity use throughout much of the study area, with little to no shipping occurring in Willapa Bay and in near shore (3nm or less, which are State regulated waters (NOAA Office of Coast Survey, 2015)) waters. All maps show that throughout much of the MSP study area there is high-intensity use with specific areas of low-intensity use (Figure 1h). When only environmental datasets are mapped (Figure 1g), high-intensity use areas can be seen in the northern portion of the MSP study area. This is mostly driven by the OCNMS and EFH, both of which are recognized as important by the OCNMS and agencies due to the regulations that uphold these areas.

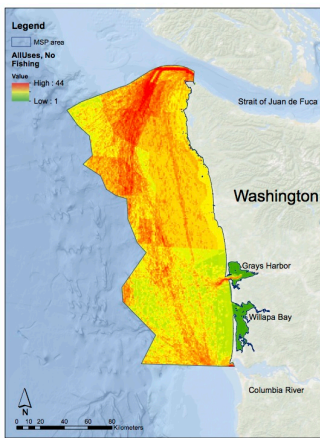
Figure 1. Maps of cumulative intensity within the MSP study area. (Note: the scale for intensity varies for each map.)



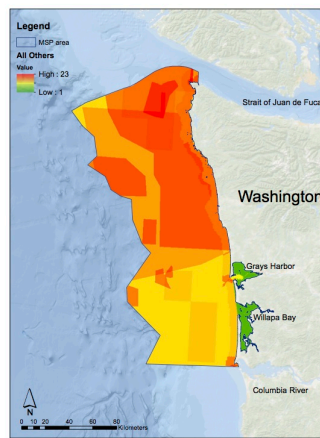
a. Cumulative intensity for all 27 datasets.



b. Cumulative intensity for all datasets, except shipping.

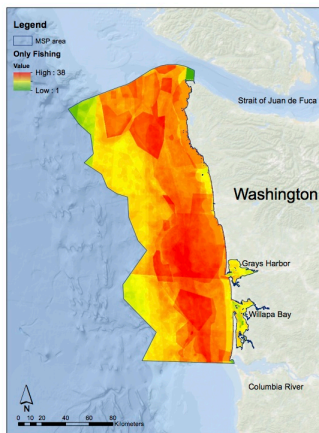


Basemap credits: Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors

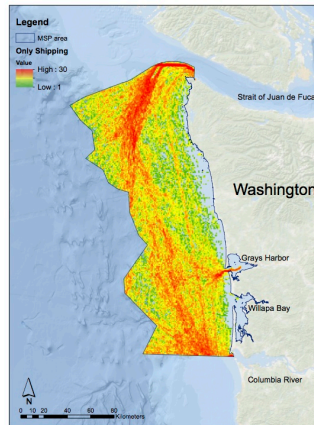


Basemap credits: Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors

c. Cumulative intensity for all datasets, except fishing. d. Cumulative intensity for all other datasets, shipping and fishing excluded.

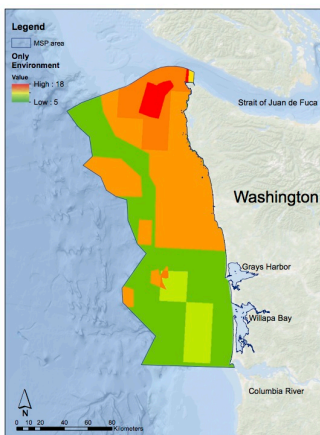


Basemap credits: Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors

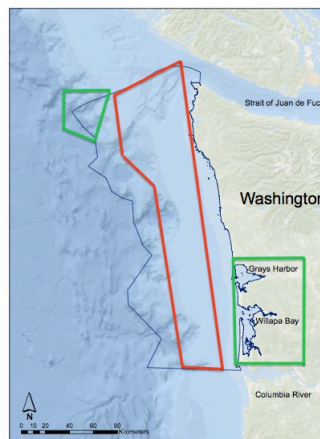


Basemap credits: Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors

e. Cumulative intensity for fishing datasets. f. Cumulative intensity for shipping datasets.



Basemap credits: Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors



Basemap credits: Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors

g. Cumulative intensity for only environmental datasets. h. Visual representation highlighting overall high and low-intensity areas. Green = low-intensity, red = high-intensity.

3.2. Conflicts with an emerging use

The Wind Power Suitability dataset was included as an emerging use due to the importance of renewable marine energy in driving the MSP process (refer to Section 1) and the availability of the dataset for inclusion. Wind Power does not rank in the top 25 largest potential conflicts and in fact ranks highest in this study as the 44th potential conflict, meaning it does not score within the top 10% of potential pairwise conflicts. The range of MCI scores related to Wind Power Suitability pairwise conflicts are mostly in the middle to lower range of MCI scores.

4. Discussion

4.1. Key Findings

Spatial and Temporal Findings

The 27 marine uses evaluated in this study demonstrate the spatial and temporal heterogeneity and the varying use intensity of activities within the Washington MSP study area. There are 38 pairs of uses (about 10% of the total pairs) that do not conflict in either space or time, or both (Table 5), showing that among a full sea of uses, it is possible for compatible pairs to exist. While these uses do not conflict in space or time, indirect conflicts between uses are possible, however an analysis of indirect conflicts is beyond the scope of this study.

Temporally, January and February are the months least burdened with uses, suggesting these months provide reduced-conflict opportunities for incorporating new uses. July and August are the most burdened with uses and may not be best fit for additional marine activities. Since permanent uses are fixed in time, the focus would be on uses that vary temporally (e.g., Washington's designated new uses of new areas for dredge material disposal or marine bio-

extraction) and can be planned to occur in less burdened months when possible. When uses allow for this, decreasing temporal overlap can help reduce conflict.

In addition to temporal gaps, the overall intensity maps highlight areas of high- and low-intensity use, both of which are important factors for spatial planning processes. When assessing current uses, high-intensity areas are logical places for managers to focus conflict mitigation efforts meanwhile low-intensity areas have the greatest potential for planning new uses. While much of the study area has medium- to high-intensity use, specific areas within all of the cumulative intensity maps (Figure 1) have low-intensity use. These areas of low-intensity use are mainly the two estuaries and the Northwest corner of the study area (Figure 1h). Although low-intensity area is limited, there are larger regions where medium-intensity use exists, mainly in deeper waters on the Western edge of the study area. High-intensity areas occur mostly in the center of the study area from the north to the south (Figure 1h). Identifying these high-intensity areas is informative as to where it might be difficult, both politically and physically, to develop new uses. Therefore, medium- to low-intensity areas may prove promising for new uses while limiting conflict with existing uses. The next step is to assess emerging uses for suitability in these areas and acknowledge that the medium- and low-intensity areas and new uses may not align.

Additionally, Figure 1e shows high-intensity use for environmental uses in the northern portion of the MSP study area. According to this study these areas are environmentally important and should be protected. Furthermore this emphasizes the potential for these areas to be environmentally significant. This information is useful for marine managers as they can work to decrease negative impacts of marine uses by citing environmentally valuable areas that should be avoided by new developments. A wider variety of environmental data should be used to hone in

on the specific areas for citing, which is currently being completed through an analysis of ecologically important areas by WDFW (Culver, Niles, and Pierce, 2015).

Together these analyses identify important months and areas within the MSP study area to focus on when developing a spatial plan. Acknowledging both spatial and temporal gaps in use as well as medium- to low-intensity spatial areas and high-intensity environmental areas provides details on when and where there may be room for potential new uses or when and where there may be challenges to incorporate future uses.

MCI Findings

Classifying the top 25 potential conflicts into three thematic groups provides important insight into the most apparent potential conflicts (Table 4). The first group, commercial fishing with commercial fishing, has high potential conflict likely due to the large area and time in which different fisheries take place. While fisheries are highly variable in both space and time, MCI scores show these fisheries may conflict significantly. Consistent with this finding three assessments of fishery conflicts all analyze these issues and address how fishery conflicts arise around the world due to differing technologies and use of the same space (Charles, 1992; Bavinck, 2005; Pomeroy et al., 2007). In the present study, Commercial Bottom Trawl has the largest potential conflict with other commercial fishing because it occurs over a large space (86% of the MSP study area) and during the entire year. Additionally, trawl gear is often the source of fishery gear conflicts (Bavinck, 2005). While commercial fishing uses may have vessel run-ins, gear conflicts, or other forms of conflict, there are extensive fisheries regulations in place to prevent interactions. For example, a social objective of the West Coast Groundfish Fishery Management Plan is to “minimize gear conflicts among resource users” and to do so they include

a socioeconomic framework to address issues such as “conflicts between competing user groups” (Pacific Fishery Management Council, 2014).

The second group, commercial fishing with Tribal U&As, may be overestimated as this dataset does not describe exactly where these tribes fish, but rather the area where tribes have the right to fish (see Section 4.2.). While tribal and non-tribal fisheries may compete for the same resources as they are often focused on similar species within the same areas, due to the Treaty Tribes’ right of up to 50% of the fish that pass through their U&A fishing areas (*United States v. Washington*, 1974; *Pacific Coast Treaty Indian Fisheries*, 2012), there is likely not a conflict between these two user groups. Although there is spatial and temporal overlap representing commercial fishing and Tribal U&As as potential conflicts, the co-management regime in federal waters likely mitigates spatial and temporal conflicts if they do arise (*United States v. Washington*, 1974).

The third group, commercial fishing with shipping collectively occurs throughout the entire year in most of the MSP study area. Both shipping and fishing datasets are some of the largest spatial and temporal uses, which can be seen by the high MCI scores of potential conflict. Vessel collisions or near-misses occur within marine waters around the world and are frequent occurrences in Washington (“Northwest Ships,” 2015), making these likely conflicts. Specifically MCI scores show high conflicts between Commercial Bottom Trawl and Shipping - Miscellaneous, Cargo, and Tug. Macrae (2009) assessed common patterns of shipping accidents and explained that collisions often occur between a fishing vessel, specifically trawlers, and either a bulk carrier or a cargo vessel, supporting the findings of the present study.

Because marine renewable energy was a main driver for Washington’s legislation in choosing to develop a spatial plan, Wind Power Suitability MCI scores aid in understanding this

potential conflict. The MCI results show that Wind Power Suitability does not exist in the top 25 largest potential conflicts and rather first appears as the 44th potential pairwise conflict. MCI scores of potential conflict show that even with MCI_{max} overestimating conflict, Wind Power Suitability only has medium to low pairwise MCI scores. Additionally, because this is a suitability dataset, an actual wind power project will require less area than the overall suitability dataset represents, making it a smaller potential conflict than portrayed here. Although renewable energy was a major impetus for developing MSP and has been given much attention, this study provides a vital first assessment for a subset of one of the main new uses in Washington and shows that conflict may be minimal. While wind power is one of three choices for consideration of renewable energy in Washington (Van Cleve et al., 2013), the findings highlight that wind power and its potential conflicts with other marine uses may be a smaller issue in the grand scheme of coastal use conflicts.

4.2. Limitations of the Study

While data used in this study may be the best publicly available datasets, the datasets are not necessarily perfect representations of uses because each dataset deals with specificity of space, time, and use-intensity differently. For example, Commercial Albacore was the largest spatial use, covering 99% of the total MSP study area (Table 2), which may be an overestimate of the actual footprint due to the data being sampled by points and then extrapolated over large areas and the highly variable inter-annual migratory patterns of albacore tuna (NOAA Fisheries, 2014). While this is a good representation on a large scale and is likely better than no data at all, only six data points represent the entire study area. Additionally, uses like Tribal U&As and Military Practice Areas are also likely overestimated due to lack of more specific and publically

available data that explicitly documents when and where these uses actually occur rather than when and where these uses can occur. For instance, tribal fishing data is not publically available and in order to represent this important use in the analysis the U&As stated by law (*Pacific Coast Treaty Indian Fisheries*, 2012) were used to define this fishing area rather than specific fishing data, like those used in the other fishing datasets. Also all four coastal tribe's U&As were represented as one Tribal U&A dataset, instead of four separate ones, due to the legally identified U&As being disputed in court during the time of this study (*United States v. Washington. Subproceeding No. 09-01.*, 2015). Lastly, although temporal representation was as accurate as possible there is room for a higher level of specificity that would create a better temporal representation for specific datasets. Most notably, both Military Practice Areas and Ocean Dredge Disposal can occur 12 months out of the year although they likely occur at intervals, rather than consistently throughout all 12 months (U.S. Army Corps of Engineers, 2014). Because they do not have set times of occurrence, these datasets are best represented as temporally occurring for 12 months out of the year. More spatial and temporal specificity within these datasets would allow for potential conflict between these uses and others to be better represented.

For this study GIS comparisons of conflicts, MCI scores, and cumulative intensity serve as a first assessment of potential conflicts within the MSP study area, but they are only a partial indicator of what the nature of the conflict and the solution might be. Because the potential pairwise conflict using MCI scores only represents spatial and temporal overlap and does not account for the possibility of compatible uses (unless there are no overlaps) and existing management measures to mitigate conflicts, empirical evidence relevant to Washington's coastal

uses in the MSP study area is needed to fully understand if these potential conflicts are actual conflicts and find solutions to decrease specific conflicts.

4.3. Ground truthing

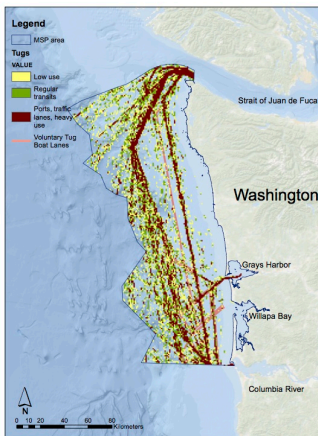
Three examples of MCI scores coupled with empirical evidence highlight the usefulness of MCI scores in focusing in on potential conflicts and the need for empirical evidence to define actual marine conflicts or compatibilities in Washington.

Along the Washington coast, cooperative agreements between uses help decrease actual conflict. Two examples of groups of uses that were included in this analysis both confirm that these agreements have been successful in decreasing conflict as shown by low MCI scores. The first pair of uses is Shipping – Tugs and Commercial Crab, which have a low MCI score (0.2846 MCI). In the 70's both sectors were brought together and began the Commercial Crabber Towboat Lane Agreement Project and created voluntary tug boat lanes to reduce conflict between crabbing gear and tug boat travel (Scigliano, 2014) (Figure 2a). Figure 2a depicts the voluntary lanes and shows that in the southern portion of the MSP study area Shipping - Tugs high-intensity use coincides almost exactly with the voluntary lanes. While there may be room for improvement, over the years this completely voluntary agreement has decreased financial costs by saving the industries around \$1 million annually (Harbell, Decker, and Fisker, 2015) and increased safety for both industries (Scigliano, 2014).

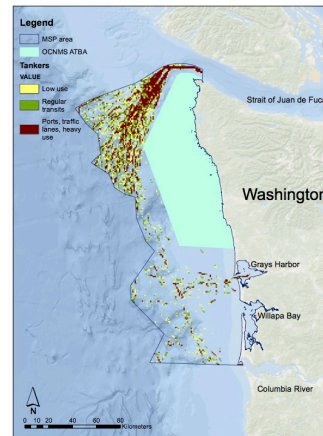
The second group of uses is OCNMS and all shipping datasets, which have medium- to low-level conflict (these range from 0.0421-0.4299 MCI scores). The International Maritime Organization has designated an Area to Be Avoided (ATBA) that advises certain vessel types to avoid a specific area both for ship and environmental safety (OCNMS, 2013; Galasso, 2000).

Figure 2b shows the ATBA and Tanker vessels, which appear to follow the boundary and avoid this area almost entirely. Tankers were specifically mapped due to their high potential for oil spills if an accident occurs and the OCNMS and ATBA targeting these vessels to protect the natural habitat from oil spills (Galasso, 2000). The OCNMS reports that vessel compliance with the voluntary ATBA ranges from 36.4% to 100% with an average compliance of 97% among all vessels (OCNMS, 2013). Thus, the collaborative efforts facilitated communication and minimized conflicts. Such efforts are important for the future of conflict resolution in marine areas.

Figure 2. Maps demonstrating cooperative agreements.



a. Map of Voluntary Tug Boat Lanes with Tug boat vessel density.

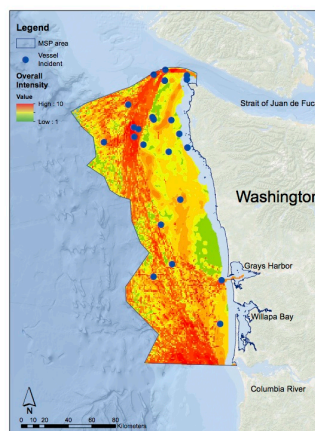


b. Map of OCNMS Area to Be Avoided with Tankers vessel density

In addition, high MCI scores were verified as being useful to highlight actual conflict. Of the three groups of potential conflicts identified by the analysis (Section 4.1.2), the group most likely to have actual conflict is commercial fishing and shipping. A specific potential conflict with a high MCI score (0.7179 MCI) is Commercial Bottom Trawl and Shipping – Cargo. Pairing this with collision and near-miss (an incident where something went wrong that could

have resulted in an injury, casualty, or release of a product) data from OCNMS transforms potential conflict into actual conflict. Although not all of the collisions and near-misses mapped are explicitly between Commercial Bottom Trawl and Shipping – Cargo these data were the best available data representing collisions and near-misses in this area and can be used as a proxy to better understand this conflict. The data mapped on top of the overall intensity for Commercial Bottom Trawl and Shipping – Cargo show that these collisions and near-misses match up with the high-intensity use areas (Figure 3). In addition, some collisions and near-misses do occur outside of the high-intensity use areas, which is likely due to a greater potential for conflict outside the designated shipping lanes partially because predictability of where vessels will be decreases. The financial and safety impacts of vessel collisions and near-misses make commercial fishing and shipping conflicts important to decrease (Macrae, 2009). This example shows that this group of uses should be the focus for conflict resolution and a cooperative agreement may be the logical next step to solve or decrease actual conflict between these uses.

Figure 3. Map of collisions and near-miss vessel incidents. Commercial Bottom Trawl and Cargo vessels were overlaid to show overall intensity areas.



Basemap credits: Esri, DeLorme, GEBCO, NOAA, NGS, and other contributors

Using MCI scores of potential conflict to highlight pairs of uses and reinforce findings with empirical evidence can help to describe compatibilities and conflicts and assist in finding potential solutions. By coupling empirical evidence with MCI scores, these examples confirm that MCI is useful for scoring actual conflict or compatibilities and furthering information about conflicts and compatibilities between uses. Cooperative management solutions and agreements can decrease conflict between pairs of uses and may become increasingly important to minimize conflict overall as new uses are added into Washington waters (Scigliano, 2014). Finding solutions to marine conflicts is no easy task as shown by the breadth of uses analyzed in this study, but mitigation of specific space and time conflicts are fundamental elements for dealing with existing conflicts before solving potential conflicts between these uses and future uses.

5. Conclusion

As Washington uses MSP to develop a plan and meet the mandated goals of the process, a thorough assessment of current use and potential conflicts is necessary. The present study fills this information gap and offers unique findings that can greatly aid the state's planning process. In order to assess future uses along the coast, the current state of the ocean and its activities, specifically the interactions between current uses, must be the foundation of any MSP effort. This study shows how marine uses vary in space, time, and intensity and gives a much-needed first assessment of current uses and their potential conflicts. This information on potential and actual conflicts and compatibilities can help increase coordination and management across uses by understanding current conditions to aid in developing a spatial plan for incorporating the designated new uses.

Overall, with January and February having the least amount of uses during the year and Grays Harbor, Willapa Bay, and the Northwest corner of the boundary being low-intensity areas, these times and areas may be best fit for the addition of new uses in order to reduce intensifying conflict. Wind Power Suitability may be a smaller conflict than is generally accepted, emphasizing that while renewable energy is included for consideration in the MSP process, its conflict with current uses may prove small. Most importantly, by adding empirical evidence and strengthening MCI scores of potential conflict with evidence-based actual conflict, future research will shed light on more conflicts and compatibilities in the MSP study area. This study highlights the potential for cooperative agreements to begin to solve specific conflicts thereby contributing to a reduction in overall conflict, especially when new uses are considered. For example, the group of largest potential conflicts involving commercial fishing with shipping may be most important to focus conflict resolution efforts before adding additional uses through the MSP process.

While the focus of this study is on Washington and marine waters, this methodological approach is applicable for all planning processes. The tool provided here can be used to assess the footprint of current uses and analyze potential conflicts with spatial, temporal, and use-intensity data to improve future planning endeavors.

MSP is a much-needed process for managing the ocean's resources for sustainable use today and in the future. It can provide guidance for producing a well-informed, cohesive, and conflict-reducing spatial plan, especially when decision-makers are provided with information to understand the current state of the oceans and the interactions between uses. With better informed planners, managers, and users, conflict can be reduced even while demand increases for precious marine space and resources.

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7. Appendices

Appendix A: Datasets descriptions and maps

Table 1. Descriptions for each of the datasets used in the study, including the MSP Boundary dataset.

Datasets	Description	Source of Description
MSP Boundary Polygon	Area in which WA is developing a plan. Bound by coastline of WA, including Willapa Bay and Grays Harbor, and goes out to 700 fathom contour. This includes islands/rocks that are on the coastline (these were not included in WDNR's MSP Boundary layer from - left them in b/c these are areas where uses cannot occur due to rocks/islands being in the way)	
Commercial Fishing Data	Each layer has data varying by use: No use, Trace, Low, Moderate, Elevated, High	
Albacore	Fishing locations of WA-based commercial troll vessels on trips targeting albacore tuna (<i>Thunnus alalunga</i>) generalized to 1-degree blocks	http://www.msp.wa.gov/explore/data-catalog/
Coastal Crab (Dungeness)	Data represent commercial Dungeness crab landings, data created by the WDFW in 2014 from available catch effort landing information	http://www.msp.wa.gov/explore/data-catalog/
Pink Shrimp	Data represent pink shrimp catch effort, data created by the WDFW in 2014 from available catch effort landing information for vessels targeting pink shrimp	http://www.msp.wa.gov/explore/data-catalog/
Sardine	Data represent commercial sardine fishery catch effort, data created by the WDFW in 2014 from available vessel catch information	http://www.msp.wa.gov/explore/data-catalog/
Bottom Trawl (Groundfish)	Data represents the fishing effort of vessels targeting groundfish species using bottom trawl gear, data created by WDFW in 2014 from available catch effort landing information. Commercial groundfish species include rockfish, cabezon, kelp greenling, Pacific cod, sablefish, flat fish, and lingcod	http://www.msp.wa.gov/explore/data-catalog/
Mid-water Trawl (Pacific Whiting)	Data represent commercial Pacific Whiting closure areas which are closed to mid-trawl methods in Washington coastal waters. The data were created by the WDFW in 2014 from available closure information.	http://www.msp.wa.gov/explore/data-catalog/
Tribal U&As	Data depict the Usual and Accustomed areas defined by law to the four coastal Washington tribes in 50 CFR 660.50 - Pacific Coast treaty Indian fisheries. This layer uses the GPS coordinates specified in 50 CFR 660.50 and was created in January of 2015. It should be noted that while each of the four coastal Treaty Tribes have specific U&As, this layer combines those, mostly due to several reasons such as the current legal challenge to these areas.	50 CFR 660.50
Recreational Fishing Data	All layer organized by priority: high or medium	
Albacore	Data represent recreational fish landings for albacore tuna, data created by WDFW in 2014 from available catch effort landing information	http://www.msp.wa.gov/explore/data-catalog/
Bottomfish	Data represents recreational bottomfish and lingcod fishery target areas, data created by WDFW in 2014 from available catch effort landing information. Data include all species of rockfish, cabezone, kelp greenling, Pacific cod, sablefish, flat fish, and lingcod	http://www.msp.wa.gov/explore/data-catalog/
Hallibut	Data represent recreational fish landings for Pacific halibut species, data created by WDFW in 2014 from available landing and management information	http://www.msp.wa.gov/explore/data-catalog/
Salmon	Data represent high and medium priority areas for recreational anglers targeting salmon species in coastal waters, data created by WDFW in 2014 from available closure information	http://www.msp.wa.gov/explore/data-catalog/
Commercial Intertidal Harvest	Data represent marine waters used for commercial intertidal harvest, which includes commercial harvest in the intertidal zone of living marine plant or animal species for consumption or aquaria. Harvesting for clams is also a significant within the study area. Data comes from a participatory mapping workshop with BOEM and NOAA. The two bays account for nearly 10 percent of oyster production in the US.	http://www.msp.wa.gov/explore/data-catalog/
Recreational Intertidal Harvest	Data represent marine waters used for recreational intertidal harvest, which includes recreational harvest in the intertidal zone of living marine plant or animal species for consumption or aquaria. Recreational intertidal harvest occurs throughout the study area for a wide range of clam species (razor, butter, horse, and manila clams) and crabs. Data comes from a participatory mapping workshop with BOEM and NOAA.	http://www.msp.wa.gov/explore/data-catalog/
Ocean Dredge Disposal	Dredging and ocean disposal sites verified by WDOE. Composed of 4 separate layers: Disposal and Beneficial Use Grays Harbor (3.9 mile ocean site, half moon bay, south jetty, point chehalis, and south beach), Disposal Boundary Grays Harbor, Dredged Material Disposal Sites (deepwater site, north jetty, shallow water site, south jetty, and federal navigation channel and centerline), and Federal Navigational Channels for Columbia, Quillayute, and Grays Harbor.	WDNR
Military Practice Areas	Data depict the location of areas in which naval, military or aerial exercises are executed. *Note: Military is authorized to use the entire MSP boundary, but this shows a commonly used site along the coast. This layer includes data from the participatory mapping workshop to show high use and low use areas and combines this with the W-237 Washington Coastal Warning Area, an area used routinely, to show medium use areas.	http://www.globalsecurity.org/military/facility/pacnorwest.htm
Shipping Densities	Vessel densities from data was gathered by vessels Automatic Identification System (AIS) transceivers received by satellite in 2013. Density maps represent all vessels that have transited the Washington Outer Coast and that have an AIS transponder.	http://olympiccoast.noaa.gov/protect/incidentresponse/2013_ais.pdf
Cargo	Bulk Carries, General Cargo Ship, Container Ship, Refrigerated Ship, Roll-on Roll-off Cargo Ship, and Vehicle Carrier	
Fishing	Fishing Vessels	
Passenger	Cruise and Passenger Ships	
Tug	Tugs	
Tanker	Chemical Carrier/Tanker, Liquefied Gas Carrier, and Oil Tanker	
Miscellaneous	Cable Layer, Dredger, Drill Ship, Pollution Control, Private Vessel, Public Vessels, Research Ship, and Supply Ship	
Wind Power Suitability	Data depict areas of suitability for wind power along the Washington Coast. This shows annual average wind resource potential of the northwestern United States at a 50 meter height.	http://www.nrel.gov/gis/data/GIS_Data_Techology_Specific/United_States/Wind/metadata/pacific_northwest_regional_50m_metadata.htm
Essential Fish Habitat Conservation Areas	Data depict EFH conservation areas, coordinate locations are from National Marine Fisheries Service's Final Rule to implement Amendment 19 to the Pacific Coast Groundfish Fishery Management Plan (71 FR 27408; May 11, 2006), which prohibits fishing w/ various gear types within these areas	http://www.msp.wa.gov/explore/data-catalog/
Southern Resident Killer Whales	Data depict the boundaries of marine areas designated as critical habitat under the Endangered Species Act for Southern Resident killer whales.	http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/critical_habitat.html
Pacific White Sided Dolphins	These data show information from 16 ship-based assessment surveys by the Southwest Fisheries Science Center from 1986-2006. Predicted annual densities were smoothed into a continuous grid of density estimates for the surveyed area. Annual grids were averaged and represent the best estimate of Pacific White-Sided Dolphin density in Washington over the past 20 years.	http://www.msp.wa.gov/explore/data-catalog/
Humpback Whales	These data show information from 16 ship-based assessment surveys by the Southwest Fisheries Science Center from 1986-2006. Predicted annual densities were smoothed into a continuous grid of density estimates for the surveyed area. Annual grids were averaged and represent the best estimate of Humpback Whale density in Washington over the past 20 years.	http://www.msp.wa.gov/explore/data-catalog/
Olympic Coast National Marine Sanctuary	These data represent the official boundary of the Olympic Coast National Marine Sanctuary, which encompasses 2,408 square nautical miles of marine waters off the Olympic Peninsula coastline. The sanctuary provides important ecological, historical, and cultural resources. It is one of 14 sanctuaries managed by the National Marine Sanctuary Program and is defined in the Code of Federal Regulations, at 15 C.F.R. Part 922.	http://www.msp.wa.gov/explore/data-catalog/

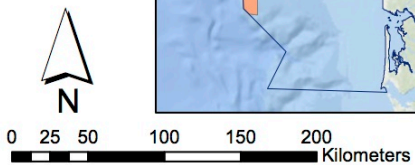
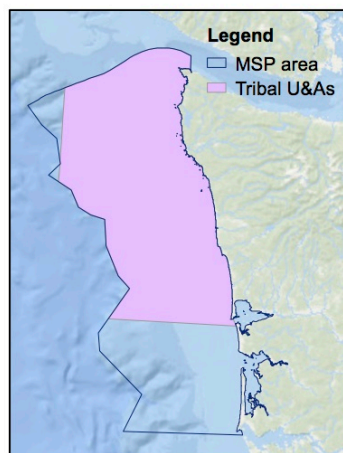
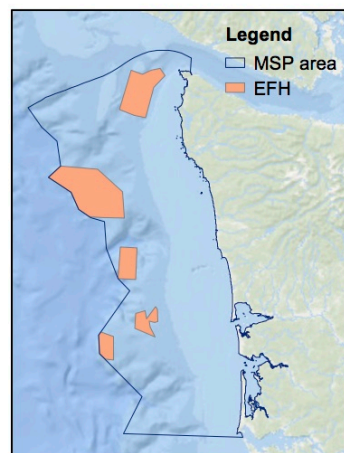
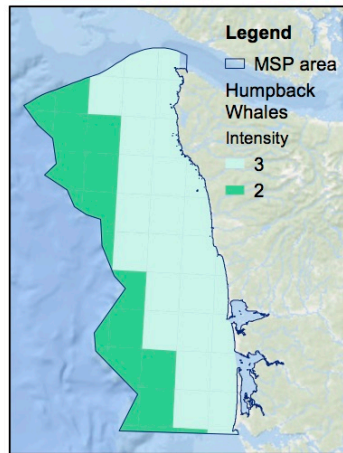
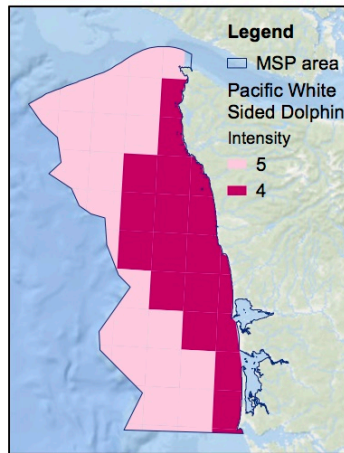
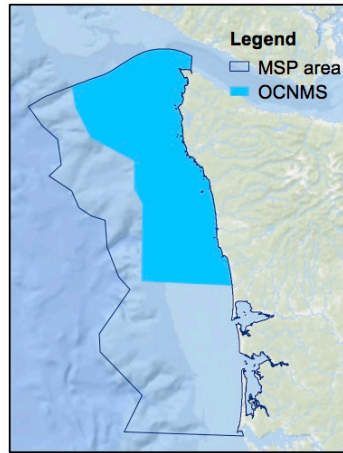
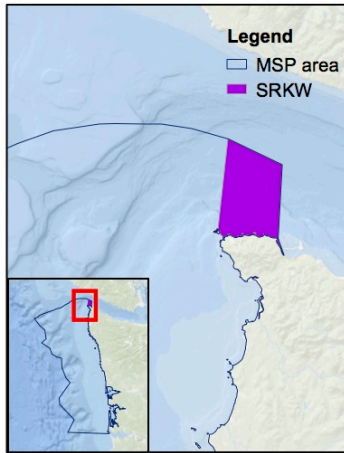
Figure 1. Map of the Washington Marine Spatial Planning study area with geographic references.

Washington Marine Spatial Planning Study Area

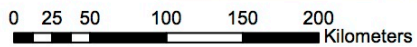
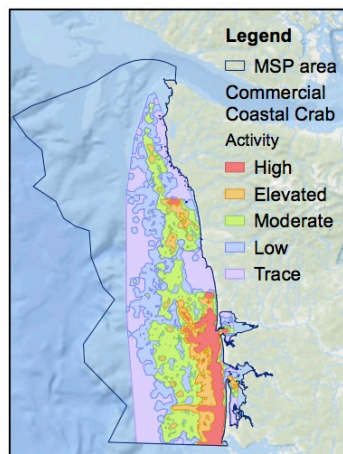
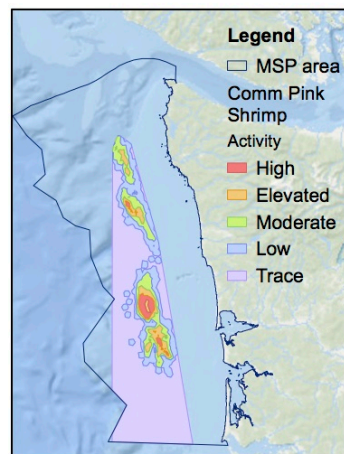
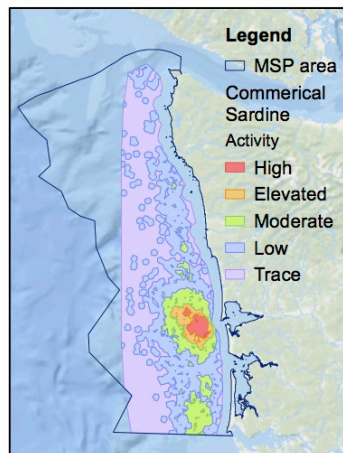
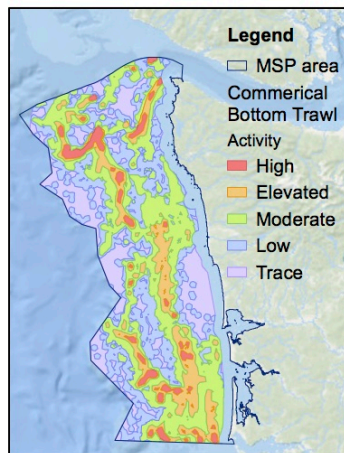
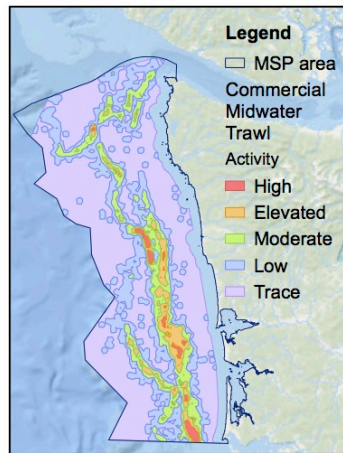
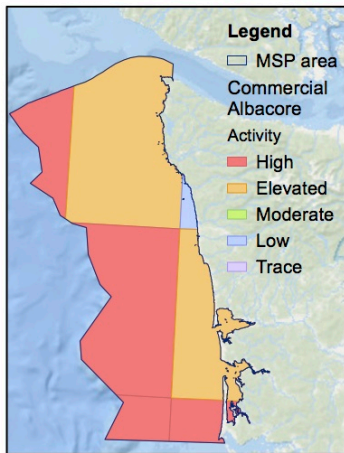


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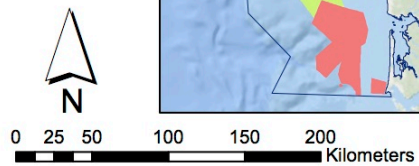
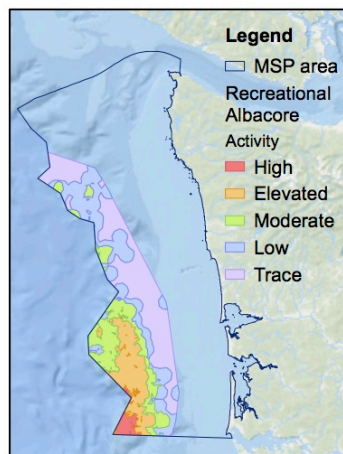
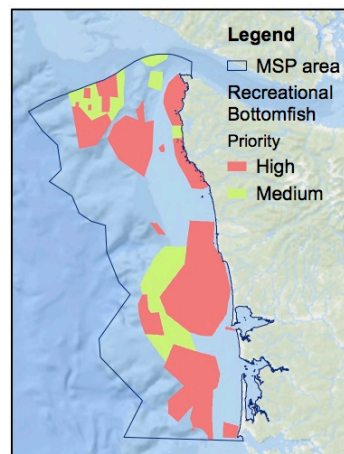
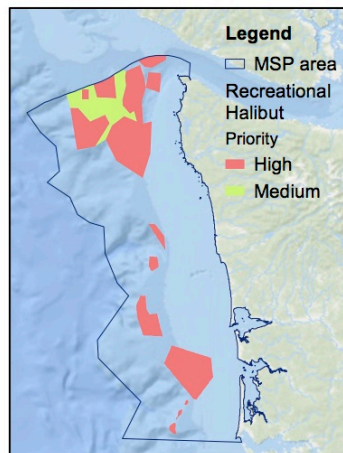
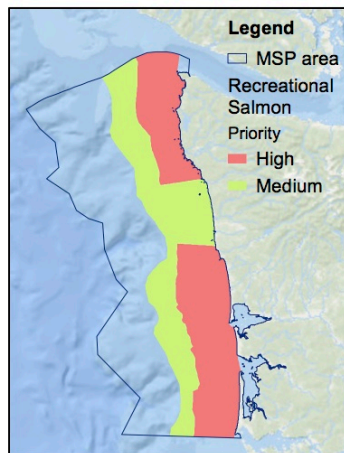
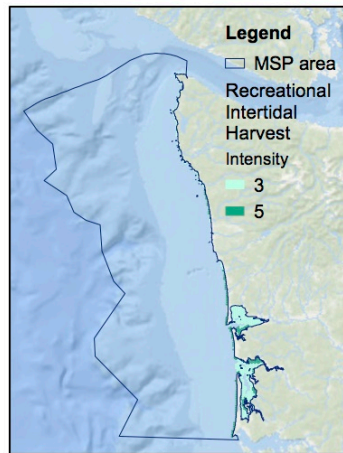
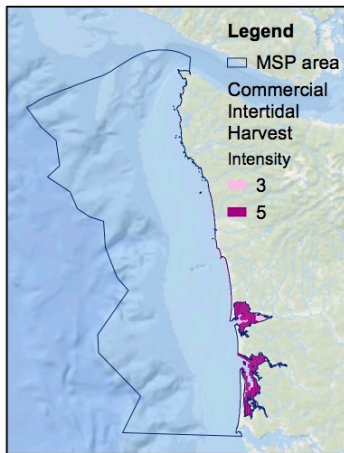
The following maps show all of the 27 datasets used in the study. Datasets with multiple colors mean use varied within the dataset. These were transferred to numerical values to represent intensity on a 1-5 scale.



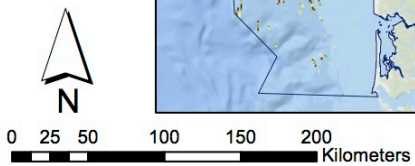
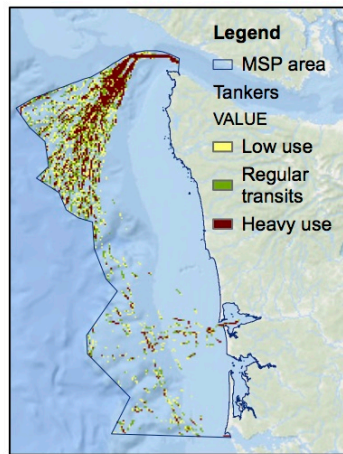
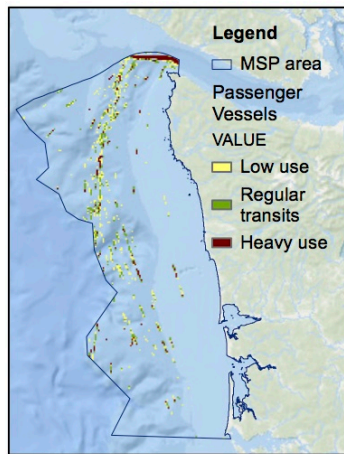
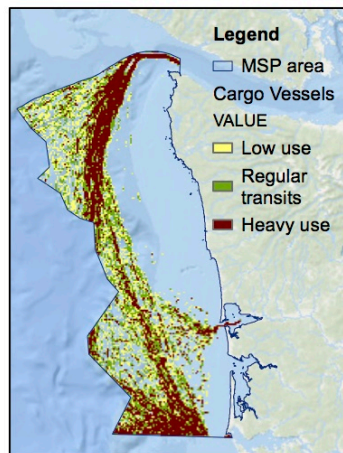
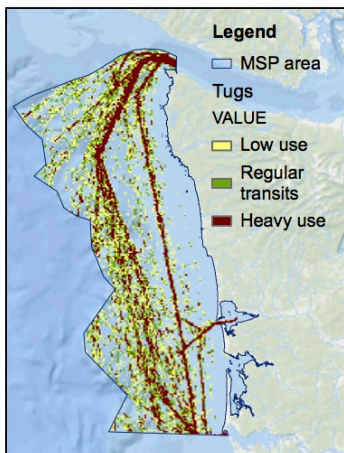
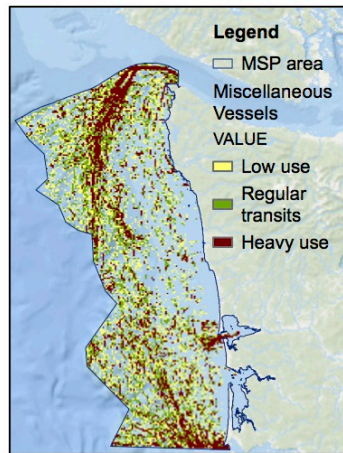
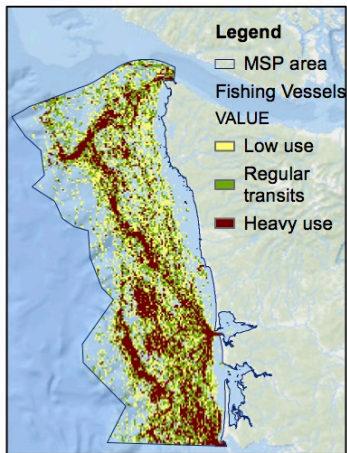
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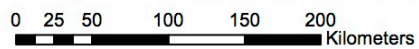
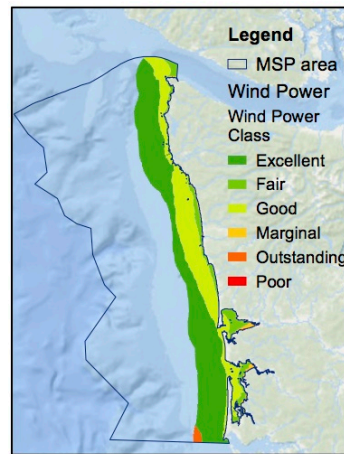
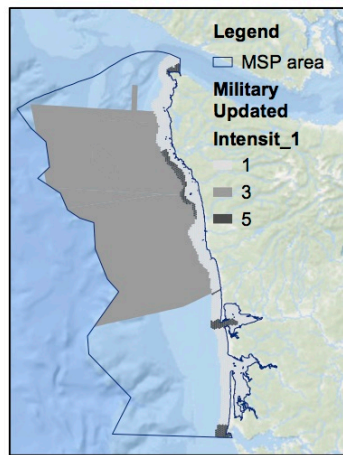
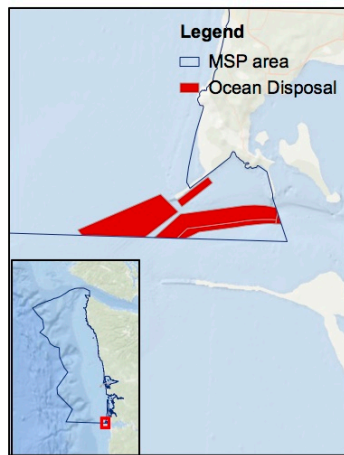
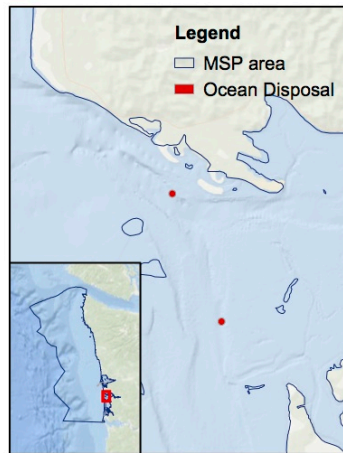
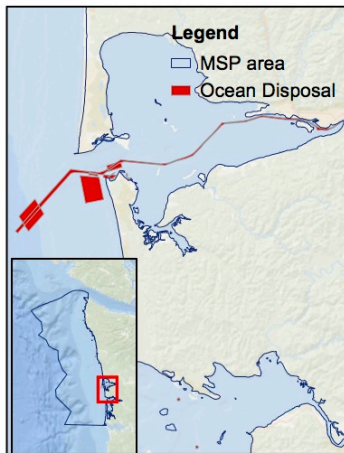
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Appendix B: MCI matrices

Below are the matrices used to calculate MCI scores. Light gray bars indicate no conflict (MCI score = 0) due to a lack of spatial and/or temporal overlap. Dark gray bars indicate no MCI scores – calculating conflict between the dataset Shipping – Fishing vessels and commercial and recreational fishing datasets was redundant and therefore not included in the MCI. For both MCI min and MCI max to get scores, the values were normalized using the maximum value so as to have MCI scores on a 1.0 scale.

MCI = spatial overlap * temporal overlap * use-intensity

MCI scores = MCI/max value

Table 1. MCI min scores

	Wind P	EFH	Military	SRKW	Ocean D	OCNMS	C Pink S	C Crab	C Sardin	C Albacc	C Whitir	C Botton	R Botton	R Halibu	R Albacc	R Salmo	S Cargo	S Fishing	S Misc	S Passer	S Tanker	S Tug	Pacific V	Humpb	Tribal U	Comme	Recreat	
Wind Power																												
EFH	0.0022																											
Military	0.0365	0.0208																										
SRKW		0.0013	0.0006																									
Ocean Disp			0.0813	0.0000																								
OCNMS			0.0664	0.0040	0.0003																							
C Pink Shrimp			0.1661	0.0091	0.0265	0.0213																						
C Crab			0.0065				0.0007																					
C Sardin				0.0004	0.0001	0.0002	0.0001	0.0001																				
C Albacc					0.0265	0.0968	0.0869	0.0833	0.0828	0.1675	0.1876	0.0161	0.0030															
C Whiting (MidTrawl)					0.0113	0.0174	0.0109	0.0136	0.0190	0.0217	0.0014	0.0084																
C Bottom Trawl								0.0258	0.0134	0.0146	0.0367	0.0481	0.0013	0.0044														
R Bottomfish									0.0228	0.0046	0.0409	0.0392	0.0021	0.0075	0.0487	0.0148												
R Halibut													0.0084	0.0027														
R Albacc															0.0052	0.0099												
R Salmon																0.0173												
S Cargo																		0.0253	0.0295	0.0040	0.0133	0.0250	0.0423	0.0211	0.1203	0.0002	0.0002	
S Fishing																			0.0336	0.0032	0.0087	0.0291	0.0591	0.0295	0.1977	0.0002	0.0003	
S Misc																				0.0038	0.0119	0.0269	0.0503	0.0251	0.1642	0.0004	0.0008	
S Passenger																					0.0021	0.0038	0.0049	0.0025	0.0217			
S Tankers																						0.0088	0.0164	0.0082	0.0645	0.0002	0.0001	
S Tug																							0.0420	0.0210	0.1398	0.0003	0.0003	
Pacific White Sided Dolphin																								0.1907	0.3260	0.0013	0.0022	
Humpback Whales																										0.1630	0.0006	0.0011
Tribal U&As																											0.0071	0.0112
Commercial Intertidal Harvest																												0.0243
Recreational Intertidal Harvest																												

Table 2. MCI max scores

	Wind P	EFH	Military	SRKW	Ocean D	OCNMS	C Pink S	C Crab	C Sardin	C Albacc	C Whitir	C Botton	R Botton	R Halibu	R Albacc	R Salmo	S Cargo	S Fishing	S Misc	S Passer	S Tanker	S Tug	Pacific V	Humpb	Tribal U	Comme	Recreat		
Wind Power																													
EFH	0.0074	0.3583	0.0046	0.0020	0.2796	0.0000	0.3409	0.2009	0.2056	0.1379	0.2818	0.1156	0.0012																
Military		0.1255			0.0456	0.0138	0.0009	0.0364	0.0742	0.0890	0.1781	0.0123	0.0038	0.0551	0.0190	0.1209	0.0703	0.1130	0.0236	0.0654	0.1053	0.0445	0.0267	0.1573					
SRKW			0.0046	0.0016	0.5709	0.1567	0.4558	0.3659	0.4513	0.4306	0.4711	0.2290	0.0129	0.1126	0.2367	0.3221	0.5627	0.4543	0.0541	0.1636	0.3720	0.2564	0.1539	0.8678	0.0501	0.0616			
Ocean Disp				0.0045					0.0025																				
OCNMS				0.0000	0.0014	0.0003	0.0008	0.0002	0.0004	0.0001																			
C Pink Shrimp					0.0911	0.3327	0.2986	0.2862	0.2845	0.5755	0.2150	0.0185	0.0103	0.2263	0.1512	0.4299	0.3100	0.0421	0.1141	0.2679	0.1703	0.1022	0.6874	0.0058	0.0100				
C Crab					0.1944	0.2991	0.1865	0.2332	0.3265	0.1242	0.0080	0.1440	0.1031	0.1794															
C Sardin								0.4426	0.2308	0.2510	0.6313	0.2753	0.0076	0.0751	0.3025	0.2300													
C Albacc									0.3912	0.0789	0.7021	0.2243	0.0123	0.1290	0.2791	0.2546													
C Whiting (MidTrawl)										0.6054	0.6160	0.1672																	
C Bottom Trawl											0.7263	0.1928																	
R Bottomfish												0.3413	0.0263	0.2296	0.3176	0.7197													
R Halibut													0.0225	0.0459	0.2150	0.1596													
R Albacc														0.0161	0.0154														
R Salmon															0.0301	0.1707													
S Cargo																0.0990													
S Fishing																	0.4345	0.5067	0.0695	0.2277	0.4294	0.1817	0.1090	0.4136	0.0010	0.0009			
S Misc																		0.5767	0.0544	0.1496	0.4999	0.2539	0.1523	0.6794	0.0010	0.0020			
S Passenger																			0.0660	0.0240	0.4629	0.2160	0.1296	0.5645	0.0025	0.0043			
S Tankers																					0.0359	0.0645	0.0211	0.0127	0.0747				
S Tug																						0.1507	0.0703	0.0422	0.2218	0.0009	0.0008		
Pacific White Sided Dolphin																									0.2458	0.2801	0.0018	0.0032	
Humpback Whales																											0.1681	0.0011	0.0019
Tribal U&As																											0.0081	0.0128	
Commercial Intertidal Harvest																												0.0464	
Recreational Intertidal Harvest																													

Table 3. Spatial Overlap Matrix (km²) – area of overlap between each pair of use.

Wind Power EFH	Military	SRKW	Ocean Disp	OCNMS	C Pink Shrim C Crab	C Sardin	C Albacore	C Whiting	C Botton T	R Bottonf	R Halibut	R Albacore	R Salmon	S Cargo	S Fishing	S Misc	S Passenger	S Tanker	S Tug	Pacific Whi	Humpback	Tribal U&A	Commerci	Recreation		
Wind Power EFH	89,105	430,423	72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	1303,027	5246,281	1246,261	1504,111	997,722	783,394	
EFH		1506,223	72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	1303,027	5246,281	1246,261	1504,111	997,722	783,394	
Military			72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	1303,027	5246,281	1246,261	1504,111	997,722	783,394	
SRKW				72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	1303,027	5246,281	1246,261	1504,111	997,722	
Ocean Disp					72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	1303,027	5246,281	1246,261	1504,111	
OCNMS						72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	1303,027	5246,281	1246,261	
C Pink Shrim							72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	1303,027	5246,281	
C Crab								72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	1303,027	
C Sardin									72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	166,296	
C Albacore										72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	131,921	
C Whiting (MidTrawl)											72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	2037,549	
C Botton Trawl												72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	1116,062	
R Bottonfish													72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	899,164	
R Halibut														72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	528,913	
R Albacore															72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	174,568	
R Salmon																72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	2379,214	
S Cargo																	72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	1387,914	
S Fishing																		72,883	24,116	156,898	18,428	811,002	1215,975	558,513	111,864	
S Misc																			72,883	24,116	156,898	18,428	811,002	1215,975	558,513	
S Passenger																				72,883	24,116	156,898	18,428	811,002	1215,975	558,513
S Tanker																					72,883	24,116	156,898	18,428	811,002	1215,975
S Tug																						72,883	24,116	156,898	18,428	811,002
Pacific White Sided Dolphin																							72,883	24,116	156,898	
Humpback Whales																								72,883	24,116	
Tribal U&As																									72,883	
Commercial Intertidal Harvest																										
Recreational Intertidal Harvest																										

Table 4. Temporal Matrix (total months out of the year) – months of overlap between each pair of use.

Wind Power EFH	Military	SRKW	Ocean Disp	OCNMS	C Pink S C Crab	C Sardin	C Albacc	C Whitr	C Botton	R Botton	R Halibu	R Albacc	R Salmo	S Cargo	S Fishing	S Misc	S Passer	S Tanke	S Tug	Pacific V	Humpb	Tribal U	Comme	Recreati	
Wind Power EFH	12	12	9	12	12	7	10	9	5	6	12	7	1	5	5	12	12	12	12	12	3	3	12	12	
EFH		12	9	12	12	7	10	9	5	6	12	7	1	5	5	12	12	12	12	12	3	3	12	12	
Military			9	12	12	7	10	9	5	6	12	7	1	5	5	12	12	12	12	12	3	3	12	12	
SRKW				9	9	7	7	8	5	6	9	7	1	5	5	9	9	9	9	9	3	3	9	9	
Ocean Disp					9	7	7	10	9	5	6	12	7	1	5	5	12	12	12	12	3	3	12	12	
OCNMS						7	10	9	5	6	12	7	1	5	5	12	12	12	12	12	3	3	12	12	
C Pink Shrim							6	7	4	5	7	6	1	5	5	7	7	7	7	7	3	3	7	7	
C Crab								7	3	4	10	7	1	4	5	10	10	10	10	10	3	3	10	10	
C Sardin									5	6	9	6	1	5	5	9	9	9	9	9	3	3	9	9	
C Albacore										5	3	4	3	5	5	5	5	5	5	5	2	2	5	5	
C Whiting (MidTrawl)											6	4	6	6	6	6	6	6	6	6	3	3	6	6	
C Botton Trawl												7	1	5	5	12	12	12	12	12	3	3	12	12	
R Bottonfish													1	4	5	7	7	7	7	7	3	3	7	7	
R Halibut														1	1	1	1	1	1	1	1	1	1	1	
R Albacore															4	5	5	5	5	5	3	3	5	5	
R Salmon																5	5	5	5	5	3	3	5	5	
S Cargo																					3	3	5	5	
S Fishing																						3	3	12	12
S Misc																							3	3	
S Passenger																								12	
S Tanker																								12	
S Tug																								12	
Pacific White Sided Dolphin																								3	
Humpback Whales																								3	
Tribal U&As																								12	
Commercial Intertidal Harvest																								12	
Recreational Intertidal Harvest																								12	

Table 5. Intensity Matrix minimum (1-5 scale) – to calculate min intensity, the lowest intensity value for each dataset was taken. For the matrix, these values were multiplied for each pair of uses.

Wind Power EFH	Military	SRKW	Ocean Disp	OCNMS	C Pink S C Crab	C Sardin	C Albacc	C Whitr	C Botton	R Botton	R Halibu	R Albacc	R Salmo	S Cargo	S Fishing	S Misc	S Passer	S Tanke	S Tug	Pacific V	Humpb	Tribal U	Comme	Recreati
Wind Power EFH	5	1	5	5	5	1	1	1	1	1	3	3	1	3	1	1	1	1	1	1	4	2	5	3
EFH		5	25	25	25	5	5	5	5	5	15	15	5	15	5	5	5	5	5	5	20	10	25	15
Military			5	5	5	1	1	1	1	1	3	3	1	3	1	1	1	1	1	1	4	2	5	3
SRKW				5																				

Table 6. Intensity Matrix maximum (1-5 scale) – to calculate max intensity, the highest intensity value for each dataset was taken. For the matrix, these values were multiplied for each pair of uses. Because all datasets aside from one have highest intensity of 5, MCI max scores were driven mostly by spatial and temporal results.

	Wind P	EFH	Military SRKW	Ocean D	OCNMS	C Pink S	C Crab	C Sardin	C Albacc	C Whitir	C Bottor R	Bottor R	R Halibu	R Albacc	R Salm	S Cargo	S Fishiq	S Misc	S Passer	S Tanke	S Tug	Pacific V	Humpb	Tribal U	Comme	Recreati
Wind Power	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
EFH		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Military			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
SRKW				5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Ocean Disp					5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
OCNMS						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C Pink Shrimp							5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C Crab								5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C Sardin									5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C Albacore										5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C Whiting (MidTrawl)											5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C Bottom Trawl												5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
R Bottomfish													5	5	5	5	5	5	5	5	5	5	5	5	5	5
R Halibut														5	5	5	5	5	5	5	5	5	5	5	5	5
R Albacore															5	5	5	5	5	5	5	5	5	5	5	5
R Salmon																5	5	5	5	5	5	5	5	5	5	5
S Cargo																	5	5	5	5	5	5	5	5	5	5
S Fishing																		5	5	5	5	5	5	5	5	5
S Misc																			5	5	5	5	5	5	5	5
S Passenger																				5	5	5	5	5	5	5
S Tankers																					5	5	5	5	5	5
S Tug																						5	5	5	5	5
Pacific White Sided Dolphin																							5	5	5	5
Humpback Whales																								5	5	5
Tribal U&As																									5	5
Commercial Intertidal Harvest																										5
Recreational Intertidal Harvest																										5