Oregon Sea Otter Reintroduction Economic Study, Initial Estimates of Economic Impact and Discussion of Economic Value

Report to Elakha Alliance from
The Research Group,
Corvallis, Oregon
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Preface

NOTE: This document is an abridged version of the full report Oregon Sea Otter Reintroduction Study, Initial Estimates of Economic Impact Discussion of Economic Value May, 2022, available from the Elakha Alliance.

In recent years there has been renewed interest in the possibility of reintroducing sea otters to Oregon. Sea otters were extirpated in Oregon by the early 1900s. Sea otters are a keystone species—a species that significantly and disproportionately affects the structure and function of the surrounding ecological community. A successful sea otter restoration program could help restore the ecological functions generated by such a keystone species, restore the deeply rooted cultural links between sea otters and human residents along Oregon's coast, and help ensure that sea otters on the U.S. west coast can survive potentially catastrophic events, such as oil spills, through a broader distribution of their populations. However, reintroduction of sea otters on the Oregon coast will affect existing ecological relationships that have human dimensions.

The Elakha Alliance, an Oregon-based nonprofit, is cooperating with the U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife (ODFW), and other partners to explore the possibility of restoring sea otters to Oregon. In 2021-22 the Elakha Alliance commissioned a scientific feasibility study to determine whether existing habitat, source populations, and political, legal, economic, and social contexts are suitable for a successful reintroduction of sea otters to Oregon. Among many other topics, the feasibility study explores social and economic impacts, both positive and negative. The final Restoring Sea Otters to the Oregon Coast: A Feasibility Study may be accessed online at https://www.elakhaalliance.org/feasibility-study/.

As part the feasibility study, the Elakha Alliance contracted with The Research Group, LLC (TRG) of Corvallis, Oregon, to conduct an initial analysis of the economic impacts of sea otter reintroduction in Oregon. That analysis explores the potential economic impacts of having a sustainable population of sea otters in four specific coastal areas, which would be expected to occur approximately 25 years in the future if sea otter reintroduction succeeds. It should be noted, however, that data and impact modeling results on the potential ecological consequences of sea otter reintroduction on the Oregon coast are limited. The full report from TRG is Oregon Sea Otter Reintroduction Study, Initial Estimates of Economic Impact Discussion of Economic Value May, 2022

The economic impact study contains four chapters, a bibliography and appendices:

- Chapter One introduces the study purpose and sets out four possible alternate reintroduction locations.
- Chapter Two provides a brief economic description of Oregon fisheries, including those that could be negatively affected by sea otter reintroduction (termed "at-risk fisheries"), and describes Oregon coast outdoor recreation and visitor levels.
- Chapter Three describes estimating methods and modeling results for economic impacts to fisheries and tourism at the four alternative locations.
- Chapter Four discusses ecosystem services and an "existence" or intrinsic value for sea otters.
- Appendix A discusses other economic analysis methods that could be used to evaluate the reintroduction program.
- Appendix B describes the nearshore spatial economic contribution model used to determine status quo conditions for affected fisheries.

Executive Summary of the Economic Analysis

The reintroduction of sea otters on the Oregon coast will affect existing ecological relationships that will have human dimensions. Because no sustainable population of sea otters currently exists on the Oregon coast, this study of potential economic effects is necessarily speculative and employs several methods to assess and describe possible future conditions.

Sea otter populations are known to be highly localized and expand slowly over time. It will take several decades for a small population released in an area on the Oregon coast to increase in numbers sufficient to begin to seek and occupy other more distant habitats. Thus, the potential effects of reintroducing sea otters are expected to be somewhat localized for many years. In order to conduct an economic analysis of a sea otter population, the authors of the Elakha Alliance Feasibility Study identified four areas on the Oregon coast into which sea otters could reasonably be reintroduced and within which a population of 200 animals could be expected to be present after 25 years. The *Oregon Sea Otter Population Model* (see below) contained in Appendix A of the Feasibility Study were used to identify the four scenario areas (depicted in Figure 1).

- Cape Arago/Coos Bay (Coos County)
- Yaquina Bay/Otter Rock (Lincoln County)
- Port Orford/Cape Blanco (Curry County)
- Rogue Reef/Crook Point (Curry County)

This study examines four topics:

- Economic impacts on "at-risk fisheries," oyster aquaculture and tourism in each of the four reintroduction scenario areas;
- The value of ecosystem services for altered kelp and seagrass volumes;
- The "existence value" of a sustained presence of sea otters; and
- An exploration of other economic analysis methods that would be helpful for decisionmakers.

Other investigators have studied the impacts of the return of sea otters to other areas. (Loomis 2005, McDowell Group 2011, Larson et al. 2013, Aldrich et al. 2001, Gregr et al. 2020a, Martone et al. 2020, Salomon et al. 2015, International Working Group on Coastal Blue Carbon 2011, Davis et al. 2019). These studies contributed to this economic investigation.

There are many ways to measure the value of a product, economic sector, or service. The following measures were chosen to be most understandable to decisionmakers:

- Income, including a multiplier effect, is used to measure economic impacts on fisheries and tourism;
- A monetary value for the carbon sequestration created by increased volumes of kelp and seagrasses that could increase due to the presence of sea otters, commonly referred to as a "blue carbon" value.
- Harvest value was used to measure the potential economic impacts of increasing fish stocks due to increases in kelp and seagrass habitat;

- "Willingness to pay" values derived from previous studies in other areas were used to study the "existence value" of a sustained population of sea otters on the Oregon coast.

Economic contributions were extracted from the Oregon Department of Fish and Wildlife *Interactive Model for the Broadscale Spatial Analysis of Oregon Nearshore Fisheries*. In addition, the Elakha Alliance Feasibility Study included an *Oregon Sea Otter Population Model* (ORSO) to help assess the suitability of habitats to support sea otters and to predict the future distribution and abundance of sea otters over time along the Oregon coast. Factors within the model include location and ecological and physical characteristics of release sites, the number, gender distribution, and ages of animals initially released, and other variables. Location data based on Kone (2019) and analyses conducted using the ORSO were used to identify four scenario regions expected to be able to support 200 sea otters within 25 years—a level considered to be sustainable.

Fisheries considered to be "at risk" of predation by sea otters include Dungeness crab, sea urchins, bay clams (butter, cockle and gaper), and farmed oysters[1]. Tourist activities that were mostly likely to be affected by the presence of sea otters were included in economic impact calculations.

The economic investigation shows reintroduction could have an overall positive economic impact to the Oregon Coast.

Cape Arago/Coos Bay is predicted to have the highest net loss in fisheries/aquaculture that are at risk of predation by sea otters, and the lowest gains in tourism.

Yaquina Bay/Otter Rock is predicted to have the lowest net losses in at-risk fisheries/ aquaculture, and the highest gains in tourism.

When other economic considerations are included, the reintroduction of sea otters to the Oregon Coast would provide positive existence economic value for Oregon and US residents.

While some fisheries for large invertebrates (shellfish) may be considered "at risk," an increase in kelp habitat enabled by the return of sea otters is likely to lead to increased finfish production. There may well be a tradeoff in revenue generated by increased commercial finfish catch and any loss of revenue in commercial large invertebrate fisheries. Due to analytical uncertainties, increased finfish production is not included in the economic figures in the bullets immediately below.

In summary, the investigation estimated that:

- Cape Arago/Coos Bay could have the highest net loss in fisheries/aquaculture and the lowest gains in tourism (a net -5.9% change in a status quo[2] (2019) income of $18.9 million)
- Yaquina Bay/Otter Rock could have the lowest net loss in fisheries/aquaculture and the highest gains in tourism (a net 4% increase in a status quo income of $29.1 million)
- Both Port Orford/Cape Blanco and Rogue Reef/Crook Point each could have a net 5.4% increase in income of about $17 million.

[1] Sea cucumbers and abalone are also potential targets of predation by sea otters, but fisheries for these species are closed or extremely low. In addition, predation of farmed oysters by sea otters is largely unstudied.

[2] In this document, calculations of the economic contributions use either 2019 or an annual average 2017-2019 depending on the fishery. This is because some fisheries' economic contributions are based on the *Interactive Model for the Broadscale Spatial Analysis of Oregon Nearshore Fisheries* developed for the Marine Reserve Program, ODFW. The base period of this model is an average of 2017-2019.

A successful sea otter reintroduction effort could lead to some redistribution of income between the fisheries/aquaculture and tourism sectors, since fisheries/aquaculture could experience decreased revenue while the number of tourist visits might increase. The effects of these shifts on individual workers would vary.

Measuring the existence value of a species is similarly complex. A 2006 study of a sea otter population on the Santa Barbara (California) coast found that on average, households in California gained $1.83 each for an increase of approximately 200 sea otters, or $2.32 in 2019 dollars (Loomis 2005). Transferred to Oregon with its 1.6 million households in 2019, this intrinsic value equals $3.7 million. Since the southern population of sea otters is protected under the Endangered Species Act, it can be argued that all U.S. households should be included in this calculation; however, studies have shown that intrinsic value decreases with increased distance from a restoration region (Loomis 2000).

There could be economic tradeoffs between fisheries and tourism. At the same time, potential increases in kelp habitat could lead to increased fish production.

More research and modeling of reintroduction site ecology is necessary to accurately calculate "blue carbon" values and increased fisheries revenue from additional kelp and seagrass production. (Chapter Five of the Feasibility Study discusses the connection between sea otter presence and healthy kelp forests and seagrass beds at length). Healthy kelp forests and seagrass beds contribute to carbon sequestration, decreasing the effects of global warming. However, the amount of carbon sequestered by kelp is not known and, in any event, the economic value of carbon offsets is not currently clear.

More data are needed before economic investigations can determine the carbon offset value of increased kelp and seagrass. Without this data, TRG (May 2022) used the presence of rocky seafloor as a proxy for areas where kelp could recover. Rocky seafloors are a limiting factor for kelp growth, although other environmental conditions also play a role. A 'blue carbon' value was calculated based on literature describing the kelp biomass density for these types of benthic conditions. Using this proxy approach, Port Orford/Cape Arago would have the highest potential gains in blue carbon value, and Cape Arago/Coos Bay would have the lowest.

Kelp forests and seagrass beds have other positive effects on marine ecosystems, including human activities (Smale et al. 2013, Krause-Jensen and Duarte 2016, Filbee-Dexter 2020, Hamilton et al. 2020). They reduce shoreline erosion by attenuating waves and currents. Whales feed on zooplankton and fish that occupy kelp forests, and their close presence can promote increased tourism. Kelp assists in nutrient cycling, which can decrease the severity of ocean acidification and hypoxia (Kessouri et al. 2021). Science has shown that kelp forests can increase juvenile survival and reproductive success of marketable fish species (Reisewitz et al. 2005, Markel and Shurin 2015).

Port Orford/Cape Arago would have the highest potential gains in blue carbon value, and Cape Arago/Coos Bay would have the lowest.

Although predictions of changing stock abundance of marketable fish species were not available when this analysis was completed, the economic investigation used data from another study of sea otter presence and absence (Gregr et al. 2020b). This study showed gains in nearshore commercial and recreational groundfish fisheries. The Pt. Orford/Cape Blanco location would have the highest potential gains and the Cape Arago/Coos Bay location would have the lowest.

The Port Orford/Cape Blanco location would have the highest potential gains in nearshore commercial and recreational groundfish fisheries due to improved habitat conditions as a result of sea otters, and the Cape Arago/Coos Bay location would have the lowest potential gains.

Three of the four reintroduction scenario locations had overall positive economic impacts, although with high uncertainty. A review of literature and 'benefit transfer' techniques show positive "existence" economic values for successful reintroduction. Prediction of changes to kelp forests from sea otter presence were not available, so it was necessary to use proxy methods to assess potential gains in blue carbon and increases in nearshore fisheries. Given that these analytical methods varied in detail and sophistication, a rank order approach was used to grade the economic impacts at the alternative reintroduction locations (Table ES-1).

Table ES-1: Rank order of various measures for the alternative reintroduction locations (table from Executive Summary p. ix, full report).

Measure	Alternative location			
	Yaquina Bay/Otter Rock	Cape Arago/Coos Bay	Port Orford/Cape Blanco	Rogue Reef/Crook Point
Least impact on fisheries/aquaculture of large invertebrates	3	4	1	2
Highest gains in tourism	1	4	2 (tie)	2 (tie)
Highest gains in blue carbon value	2	4	1	3
Highest gains in groundfish fisheries	3	4	1	2

Other methods such as benefit-cost analysis, cost effectiveness analysis, and multi-criteria analysis could also be used to measure the economic impacts of sea otter reintroduction.

Reintroduction may impose a conflict among seafood industry members who are affected by predation and those who support conservation. More detailed ecological research and economic analysis could provide more information for program design and policy making. The economic investigation results provide stakeholders, investors, government, and the public with information to make informed decisions about the merits of the reintroduction program.

I. Introduction

Background: Previous Studies

Reintroducing sea otters on the Oregon Coast will affect existing ecological relationships, resource use, and human connections with coastal ecology, including through fishing and tourism. Therefore, it is vital to understand the economic impacts of the proposed reintroduction program.

Sea otter population growth depends on many factors including human activities. Since funds were not available to conduct a general population survey or do in-depth non-market valuation analysis, the economic investigation relied on assumptions in developing economic impact models. Methods included relying on 'benefit transfer' analysis (transferring the results of an analysis from one location to another), as well as qualitative discussions about what would happen at alternative potential sites where reintroduction would occur. When relevant, the economic investigation recommends more rigorous analysis methods for use in the future.

There have been several other studies of potential economic impacts from sea otter reintroduction. Loomis (2005) studied the abandonment of the West Coast Sea Otter Translocation Program, which included both use and non-use ("existence") benefits derived from recreation, tourism, and ecosystem services. The McDowell Group (2011) used an economic impact analysis to show effects of sea otter reintroduction on commercial fisheries in Southeast Alaska. Larson et al. (2013) discussed the impact of sea otters on the Southeast Alaska sea cucumber fishery. Aldrich et al. (2001) explored conflicts between sea otters and the shellfish fishery in Santa Barbara and Ventura Counties, California. Gregr et al. (2020a) discussed the ecosystem services created by restored kelp forests in his discussions of sea otter presence in British Columbia. Martone et al. (2020) attempted to quantify ecosystem services in relation to tourism provided by the presence of sea otters in British Columbia. Salomon et al. (2015) discussed the ethics and justice of sea otter existence and reintroduction from an indigenous perspective. International Working Group on Coastal Blue Carbon (2011) and Frontier Scientists (2016) explored the economic benefits of blue carbon from kelp beds. Davis et al. (2019) writes about future directions in sea otter research and management.

Possible reintroduction locations and population scenarios

The Elakha Alliance Feasibility Study included an *Oregon Sea Otter Model* (ORSO). ORSO explored possible sea otter recovery patterns after reintroduction, estimating the magnitude of expected population growth and spread under different translocation and restoration scenarios.

The Feasibility Study team agreed that after 25 years, a population level of 200 animals in any of four alternative potential restoration areas would constitute a sustainable population. The four alternative locations are based on Kone (2019) defined subareas:

- Cape Arago/Coos Bay (Coos County)
- Yaquina Bay/Otter Rock (Lincoln County)
- Port Orford/Cape Blanco (Curry County)
- Rogue Reef/Crook Point (Curry County)

Figure 1 shows segments of the Oregon coast used by the *Oregon Sea Otter Population Model*. The area shown in color is the ocean area shallower than 20 fathoms or 120 feet, a total of 1,650 km2. Locations of four reintroduction scenario areas are shown. Associated estuary areas are not included in these calculations. Source map from Kone (2019). Calculations by TRG.

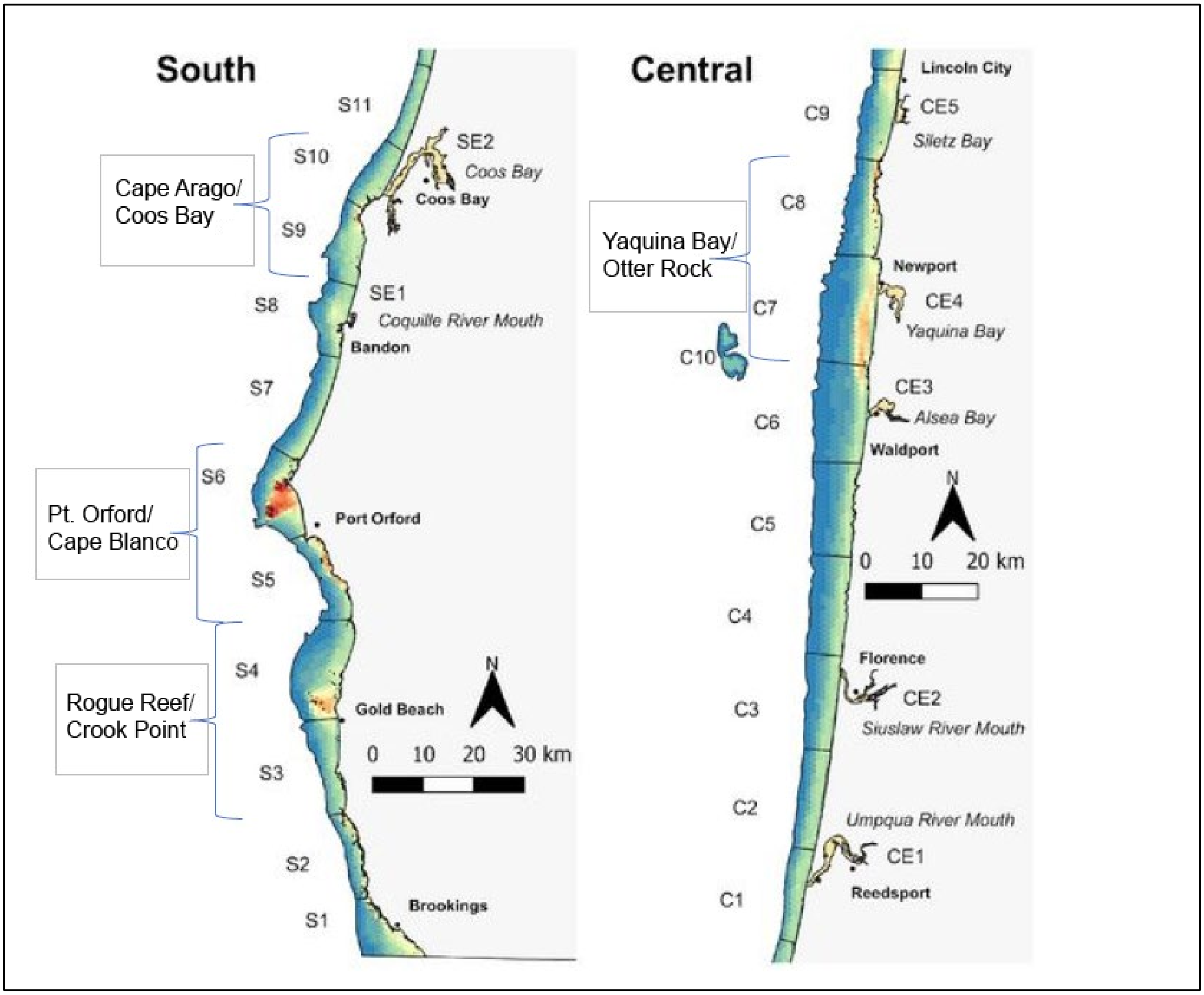

Figure 1. Translocation scenario areas used for economic impact assessment.

ORSO was used to determine the number of animals needed to be introduced in each of these areas to attain the 200-otter goal. The economic investigation uses the goal population in each of these reintroduction locations to demonstrate the potential economic effects *as if they were currently occurring*. A reintroduction plan will likely choose only one location in a pilot attempt to reach the population goal.

The ODFW *Interactive Model for the Broadscale Spatial Analysis of Oregon Nearshore Fisheries* was used to show economic contributions from current fisheries. Model results were based on average fisheries during the 2017-2019 period.

Scope of inquiry

TRG explored three areas of potential impact. The first was **direct effects on the economy from sea otter/fishery interactions** (such as in commercial fisheries for sea urchin and Dungeness crab, recreational clamming and crabbing, and shellfish aquaculture), and **effects on coastal tourism and outdoor recreation**. Existing studies were used to show economic gains and losses of the reintroduction alternatives.

Second was the **monetary value of carbon sequestration** by kelp and seagrass beds. Such value is produced through oceanic carbon markets. The discussion of blue carbon payments in this document is based on several recent studies[3]. In addition, the economic investigation discusses the **value of rockfish and other commercial species that may benefit** from increased kelp and seagrass beds.

Third was the **existence, or intrinsic, value of the sea otters in the natural environment**. Sea otters are a keystone predator whose presence promotes ecological diversity and resilience. These values are estimated using a benefit-transfer technique.

Finally, the researchers describe other economic analysis methods that would be helpful for decisionmakers.

Notes on terminology

This narrative uses different terms for economic measurements. The primary measurement is annual *economic income* (wages, salaries, business profit, etc.) accruing to affected households. The term economic income includes a multiplier effect that is calculated using input-output models. Other measures such as the number of average-wage jobs represented by a certain amount of income, business outputs, or generated taxes can also be used to measure economic income.

At times the term *economic contribution* replaces *economic impact* to characterize the economic activity being created in an existing economy. Economic impact typically describes an unadjusted shock (such as the shock of an earthquake, flood or pandemic) to an existing economy.

The term *economic value* refers to what people are willing to pay for a good or service. In this case, this value represents a "willingness to pay" for an environmental resource on the part of the public. These values can be established for a particular resource by asking the public what they are willing to pay for it to continue, whether or not payments are actually made. "Net economic value" is when all values and costs are summed.

II. Situational Analysis

Economic contribution of fisheries and aquaculture

A sea otter reintroduction program in Oregon would occur in areas with high economic activity in both commercial and recreational fisheries, as well as oyster aquaculture.

[3] Murray et al. April 2011, Pendleton 2013, Restore America's Estuaries undated, Cornu 2019

Table 1 below summarizes the angler days and economic contribution of all commercial fisheries, recreational finfish, and recreational shellfish fishing to the statewide economy (2019 numbers). About two-fifths of Oregon fisheries income in 2019 was generated by distant-water fisheries rather than fisheries along the Oregon coast[4].

Table 1: **Angler days and economic contributions of commercial and recreational fishing in Oregon** (aquaculture excluded) (Sources for values in full report: *$693 million: p.II-2, 5th paragraph; **$120 million: p. II-1, 3rd paragraph; ***$15 million: p. II-2, 1st paragraph.)

	Angler days	Economic contribution to statewide economy (income)	Job equivalent
Economic contribution of **the commercial**[5] **and recreational fishing industry** in Oregon, 2019	n/a	$693 million*	11,400 jobs
Economic contribution of select marine **recreational finfish and shellfish** fishing in Oregon, 2019	951,000	$120 million**	2,000 jobs
Economic contribution of **recreational crabbing and clamming** in Oregon, 2019 (not combined trips)	217,000	$15 million***	250 jobs

The total 2019 economic contribution generated by the fishing industry was $693 million for the statewide economy, equivalent to about 11,400 jobs. To provide some context, the fishing industry's share of the coastwide economy is 10.5 percent, although this varies considerably by region. Statewide, the contribution of fisheries is 0.5 percent.

Table 2, below, shows the economic contributions of commercial Dungeness crab and sea urchin fisheries that may be affected by sea otter reintroduction in the four alternative locations.

Table 3 shows the economic contribution of recreational shellfish fisheries taking place in Oregon bays that could be affected by sea otter reintroduction. It is difficult to account for recreational shellfish fisheries activity (defined as ocean and bay crabbing, shore and bay clamming) because there is no serial data collection for all trips. Moreover, these activities often occur in combination with other fisheries.

4 Distant water fisheries generate economic income from vessel owners, skippers and crew who spend money in Oregon using earnings made from non-Oregon fisheries such as the U.S. West Coast at-sea fishery, Washington and California fisheries, Alaska fisheries, and southern Pacific Ocean fisheries. Additional effects of distant water fisheries in Oregon include earnings at seafood processing plants, catcher processor and mothership vessels, and boat building and vessel repair facilities located in Oregon.

5 This includes commercial onshore, distant water fisheries, recreational ocean fisheries, recreational finfish fisheries located in bays and lower rivers, and recreational ocean and bay crabbing and clamming.

Table 2. Economic contributions of ***commercial Dungeness crab and sea urchin fisheries*** *(annual average 2017-2019) that may be affected by sea otter reintroduction in alternative locations.* (from Table II.4 in full report

Reintroduction location	County	Dungeness crab income	Sea urchin income	Total income
Yaquina Bay/ Otter Rock	Lincoln	$1,927,939	$9,777	$1,937,716
Cape Arago/ Coos Bay	Coos	$1,905,910	$10,266	$1,916,175
Port Orford/ Cape Blanco	Curry	$2,048,758	$192,447	$2,241,205
Rogue Reef/ Crook Point	Curry	$1,280,884	$228,333	$1,509,217

Table 3. Economic contribution of ***recreational shellfish fisheries*** *taking place in Oregon bays that could be affected by sea otter reintroduction (2019 dollars).* (from Table II.6 in full report).

	Recreational Shellfish Income			
Reintroduction location	Ocean crab	Bay crab	Clam	Total
Yaquina Bay/ Otter Rock	$182,585	$662,158	$420,004	$1,264,747
Cape Arago/ Coos Bay	$19,114	$817,910	$610,166	$1,447,190
Port Orford/ Cape Blanco	0	0	0	0
Rogue Reef/ Crook Point	$3,275	0	0	$3,275

Shellfish aquaculture, which is principally oyster farming, is not included in our estimates of economic contribution. The estimated value of shellfish aquaculture in 2019 was between $8-19.9 million, depending on method and estimator.

Table 4, below, shows the economic contribution generated by commercial and recreational fisheries within proposed sea otter reintroduction areas. It should be noted that these figures include species that are not at risk of sea otter predation, such as salmon and finfish.

*Table 4. Economic contribution of **commercial and recreational fisheries** within proposed sea otter reintroduction areas. (2019 dollars).* (from Table II.3 in full report)

Reintroduction location	County	Ocean subareas	Estuary subareas[6]	Commercial income	Recreational income	Total income
Yaquina Bay/Otter Rock	Lincoln	C7, C8	CE4	2,117,098	2,136,319	4,253,418
Cape Arago/Coos Bay	Coos	S9, S10	SE2	3,152,311	1,763,886	4,916,197
Port Orford/Cape Blanco	Curry	S5, S6		2,496,784	301,508	2,798,293
Rogue Reef/Crook Point	Curry	S3, S4		1,869,298	447,175	2,316,474

It should be noted that activities other than harvesting and processing seafood add to the commercial fishing industry's economic contribution. For example, visitors are attracted to restaurants and retail markets selling local harvests and are drawn to working waterfronts. Some ports are home to boatbuilding and gear manufacturing businesses. Management, enforcement/safety, research, education, and training also contribute to the economy. In addition, recreational anglers contribute to local economies in ways other than trip spending. For example, they purchase fishing equipment, boats, and sometimes second homes. At the same time, access to vibrant, year-round fisheries can be considered an economic development asset. Such environments attract entrepreneurs and prospective employees.

Economic contribution of tourism

Tourism contributes a substantial amount to the Oregon coastal economy. Visitors come from Oregon cities and towns as well as from around the world. Retirees, artists, and others relocate to the Oregon Coast and the area's coastal environment draws recreational anglers, wildlife enthusiasts, kayakers, and scuba divers. The coastline stretches 360 miles, punctuated by beautiful rocky headlands and sandy beaches.

Estimates of tourist spending on the Oregon coast vary. Runyan (2021) reports Oregon Coast spending in 2019 by overnight visitors to be $1.2 billion with an economic impact of $723 million. The travel industry accounted for 19 percent of the total share of the Oregon coast's total employment in 2018. Mojica et al. (2021) reports Oregon coast outdoor recreation spending in 2019 to be $5.6 billion with an economic contribution of $1.6 billion income. The economic contribution would represent 17 percent of all Oregon coast income in 2019.

Based on studies conducted elsewhere, it is likely that successful sea otter reintroduction would increase visitor rates for certain types of outdoor recreation. Of 32 activities for which Mojica et al. (2021) provide trip-related spending information, three (ocean beach, nature observations, and visiting nature centers) are seen as most likely to increase with the presence of sea otters. The spending for these activities represented about 35 percent of all outdoor recreation at the state level. These activities would occur in counties with sustained sea otter populations, and along

[6] Shore to 20-fathom isobath

shorelines with viewing access. Since Mojica's analysis of these three activities is at the state level, applying them to coastal counties is an estimate. In addition, using measurements for these activities only does not count those who might come to see sea otters who normally do not participate in nature viewing.

III. Economic Impacts on Fisheries and Tourism

Economic impacts on fisheries

Given existing fisheries and aquaculture activity, reintroducing a predator species may lead to lower harvest of certain species due to predation and altered ecology. Species that are favored in the sea otter diet are most likely to be at risk. Based on known sea otter diet consumption and diving habits, the economic investigation chose to study effects on large invertebrates such as Dungeness crab, sea urchins, bay clams (butter, cockle and gaper), and farmed oysters[7]. The areas of Dungeness crab harvest most likely to be affected by sea otters are in waters shoreward of 20 fathoms, as well as in estuaries.

The risk assumptions for each species that could be affected by sea otter predation are listed below and are the same at each reintroduction location. The factors are multiplied times economic contributions to show the intensity of potential losses. In the absence of ecological impact modeling, the economic investigation used professional judgement to settle on these risk factors. These assumptions mean, for example, that the commercial ocean crab fishery is not expected to experience losses due to sea otter reintroduction (hence 0% risk factor); that commercial sea urchin and bay mollusk fisheries are 100% likely to be impacted, that commercial bay crab is 50% likely to be impacted, etc.

- Ocean crab commercial (0%)
- Bay crab commercial: not applicable (there is negligible fishing in the affected estuaries)
- Bay crab recreational (50%)
- Sea urchin commercial (100%)
- Bay mollusk commercial (100%)
- Aquaculture with mitigation (25%)

For ocean crab commercial impacts see Grimes et al. (2020), Boustany et al. (2021), and Shanks (2021). Commercial bay crab fisheries are minimal or do not take place within the proposed reintroduction locations. Commercial sea urchin fisheries and bay mollusk fisheries could experience a total loss in reintroduction areas. Recreational bay clam fisheries could experience a 50 percent reduction. Aquaculture could experience a 25 percent reduction.

The affected commercial fisheries above represent a very minor share of what may be found at local seafood markets. Therefore, market prices are unlikely to be affected by decreases in supplies.

[7] Sea cucumbers and abalone are also considered large invertebrates, but fisheries for these species are closed or extremely low. In addition, predation of farmed oysters by sea otters is largely unstudied.

Economic impacts on aquaculture

In California, oyster growers in bays occupied by sea otters (for example, Morro Bay) use enclosures to avoid predation. It is plausible that Oregon oyster growers would similarly invest in switching from raising oysters in open cultivation to closed cultivation to prevent depredation by sea otters. Closed cultivation harvesting is more labor intensive, and profit margins for oyster farming are likely to decrease if new cultivation and harvesting techniques are introduced. The design of the reintroduction program should anticipate a request to compensate growers for the price of switching from open to closed cultivation. In many markets, the higher operating costs covered by raising prices would lower a product's competitiveness when competing with growers from other regions. California oyster aquaculture uses enclosures in sea otter populated bays to avoid predation such as in Morro Bay (Alex Manderson, ODA personal communication April 2021).

In summary, the following estimates of changes in annual "economic income" apply to each reintroduction location. Note that these numbers are derived only from impacts to species at risk of predation by sea otters. Additionally, the numbers do not include any increase in finfish due to improved habitat from sea otter presence.

Table 5. Change in generated income for certain at-risk commercial and recreational fisheries, plus oyster aquaculture, due to sea otter presence.[8] (from Table III.1 in full report)

	Annual economic value of "at risk" fisheries" and aquaculture generated in 2019	With sea otter reintroduction	Change	
Yaquina Bay/Otter Rock	$3.8 million	$3.1 million	-$0.7 million	-19%
Cape Arago/Coos Bay	$8.1 million	$6.2 million	-$1.9 million	-24%
Port Orford/Cape Blanco	$2.2 million	$2.0 million	-$0.2 million	-9%
Rogue Reef/Crook Point	$1.5 million	$1.3 million	-$0.2 million	-15%

Economic impacts on tourism

Tourism is an important economic activity on the Oregon Coast. A recent study of the economic contributions of outdoor tourism found that the three counties encompassing the four reintroduction areas (Coos, Curry and Lincoln) generated $1.1 billion in economic income in 2017 (Mojica et al. 2021).

In this study, outdoor recreation included 56 activities, of which 32 were associated with trip spending. Outdoor activities likely to be influenced by sea otter presence included **ocean beach activities** ($3.3 billion spending statewide), **nature observations** ($0.9 billion spending statewide), and **visiting nature centers** ($0.2 billion spending statewide). The value of these three activities represented about 35 percent of all outdoor recreation spending. Assuming the statewide average for these activities applies to visitation patterns in the three counties, then there is

[8] The term "risk fisheries" designates those fisheries that could be affected by sea otter presence. Data is for 2019, except data for commercial crab and sea urchins uses annual average of 2017-2019.

$390 million in economic income from all coastal counties that could be affected (positively or negatively) due to sea otter presence.

Spending associated with these activities is assumed to produce recreation-related income such as payments for boat charters or kayak rentals for viewing sea otters. A heightened interest in sea otter recovery may also lead to greater attendance at aquariums and nature centers.

It is likely that when sea otters are first introduced there will be a period of high interest by visitors, followed by a plateau period where visitors are repeat viewers and trips have multiple purposes (such as going to the beach and whale watching). Any growth rates would be expected to track the general ecotourism market.

Mojica's study of outdoor recreation did not itemize spending by activity by county. We compared such spending with the counties' geographic extent along the coastline (shoreline distances) to estimate how spending would occur in each reintroduction location. Lincoln, Coos, and Curry Counties represent 18, 15, and 22 percent of Oregon's coastline respectively, or a total of 55 percent. It is possible that sea otters would be visible and lead to increased visitation within each alternative's ocean and estuary locations. Based on road access and on-water viewing access, approximately twenty percent of Lincoln County coastline, and ten percent of Coos and Curry County coastlines, would be suitable for viewing sea otters.

Table 6 itemizes spending and labor income related to outdoor recreation by county prior to any sea otter reintroduction:

Table 6: Economic income generated by outdoor recreation for counties encompassing sea otter reintroduction locations (source: Mojica et al., 2021). (from Table III.2 in full report)[9]

	County			
	Lincoln	Coos	Curry	Total
Trip-related spending (millions)	2,077.7	1,267.0	611.8	3,956.5
Labor income (millions)	523.1	446.4	151.9	1,121.4

Table 7, below, shows the change in economic income due to presence of sea otters for the three counties where the four reintroduction scenarios are located. (Since Curry County has two reintroduction scenario locations, the economic investigation assumes that both would have the same increase in visitation and economic income change, and that new visitors would stay as long and spend as much as they do now). Increases are caused by visitors visiting the beach, observing nature, and visiting nature centers who are motivated to increase their visits knowing they may see sea otters in their natural environment.

[9] These numbers are derived by multiplying the total labor income for the three counties ($1.12 billion) by the ratio of statewide economic activity for the three categories of outdoor recreation affected by sea otter presence (.35), which equals about $390 million.

The Cape Arago/Coos Bay location would have the lowest positive impacts ($0.8 million) and the Yaquina/Otter Rock location the highest positive impacts ($1.9 million).

Summary of economic impacts on fisheries and tourism

Table 7 compares the change in the net economic contribution fisheries/aquaculture and tourism due to sea otter presence in each alternative reintroduction location. These numbers do not reflect any increase in finfish due to potential habitat improvement nor do they include carbon benefits.

Table 7: Change in economic contribution of fisheries/aquaculture and tourism due to sea otter presence. (from Table III.1 in full report)

	Reintroduction location			
	Yaquina Bay/ Otter Rock	Cape Arago/ Coos Bay	Port Orford/ Cape Blanco	Rogue Reef/ Crook Point
Value of fisheries at risk of impacts from sea otters (2019)	$3.8 million	$8.1 million	$2.2 million	$1.5 million
Value with sea otter reintroduction	$3.1 million	$6.2 million	$2.0 million	$1.3 million
Change amount with sea otter reintroduction	-$0.7 million	-$1.9 million	-$0.2 million	-$0.2 million
Change percent	-19%	-24%	-9%	-15%
Value of tourism (2019)	$25.3 million	$10.8 million	$15.6 million	$15.6 million
Change amount with sea otter reintroduction	+$1.9 million	+$0.8 million	+$1.2 million	+$1.2 million
Change percent	+0.7%	+0.7%	+0.7%	+0.7%
Value of fisheries and tourism combined (2019)	$29.1 million	$18.9 million	$17.8 million	$17.1 million
Change amount with sea otter reintroduction	+$1.2 million	-$1.1 million	+$1.0 million	+$0.9 million
Change percent	+4.0%	-5.9%	+5.4%	+5.4%

Notes: Data is 2019, except commercial portion of Dungeness crab and sea urchins uses annual average 2017-2019. Tourism status quo is for the tourism segment most likely to be influenced by sea otter viewing opportunity. Percent change is based on status quo (2019) outdoor activities in each county.

The net changes are positive for all locations except Cape Arago/Coos Bay, which had the highest income from fisheries at risk of being affected by sea otter reintroduction. Both Port Orford/Cape Blanco and Rogue Reef/Crook Point experience a net value increase of 5.4 percent.

A term like "net change" masks the fact that impacts will vary by sector. There will likely be a redistribution of income between fisheries and tourism. The tourism industry (which includes accommodations, restaurants, private transportation, etc.) would benefit from increased visitor spending, while commercial harvesters and processors of at-risk species and shellfish aquaculture businesses could see decreased revenue.

No matter which alternative is chosen, the economic impacts of reintroduction are relatively small in the aggregate. However, policy makers should consider the effects on individuals and communities. An increase in ecotourism may or may not be welcome by communities that are challenged by congestion and demands on infrastructure. Mitigation programs (such as compensation for revenue loss, job retraining, or business development) for those who are adversely affected could be included in a reintroduction program. Such elements would require additional study, including how changed ecological conditions could create additional job opportunities.

Model Uncertainty

Making public policy decisions about actions such as sea otter reintroduction is sobering because it pertains to the use of public and private funds, involves many stakeholders, and has long-term impacts to the environment.

The economic modeling in this report relies on inputs with various levels of accuracy, and the results are therefore estimates. Although the data and modeling assumptions are described in detail in the report, the complex interactions in the natural environment and in the social, economic, political systems cannot be described perfectly. As such, policy and management decisions are inherently informed judgments.

For example, using the high and low assumptions for the probability that sea otters will prey on certain fisheries, the economic impact for the Yaquina Bay/Otter Rock alternative location varies from a loss of $0.3 million in economic income to a loss of $1.1 million. On the other hand, if the number of visitors to Yaquina Bay/Otter Rock are doubled, income rises to $3.7 million.

IV. Other Ecosystem Valuation and Existence Values

Blue Carbon

The reintroduction feasibility study discusses at length the connection between sea otter presence and healthy kelp forests and seagrass beds.

Kelp inventories on the Oregon Coast show marked decline in coverage; the reasons for this change are of great interest to researchers. Sea urchins are a kelp predator and are a preferred prey of sea otters, so researchers generally expect that the presence of sea otters would lead to a decline in the number of sea urchins and thus an improvement to kelp forest health. A clearer understanding of how this relationship would apply specifically to the Oregon coast is needed, given that sea otters have been absent on the coast for over a century.

In evaluating alternative reintroduction locations, the economic investigation looked at potential increases or decreases in the value of carbon storage due to the presence of sea otters. Kelp forests and seagrass beds are efficient at sequestering atmospheric carbon from the atmosphere, and carbon sequestration has a market value.[10]

However, carbon offset projects are sometimes criticized for touting their environmental benefits while having negative secondary effects and social impacts. Sorting out these complexities is difficult. To effectively estimate the value of carbon sequestration, one would need to develop a carbon budget that included increased emissions from increased tourism and other sources. And to determine a "net present value" (an economic statistic reflecting the economic benefits of an ecosystem service), analysts would need to understand increased habitat formation over time, converted to carbon storage and combined with forecasts of carbon prices. Current offset values are in the range of $3-5 per ton of CO_2 equivalents for proven projects of high interest to voluntary buyers (Trove Research and University College London June 2021). To participate in a carbon sequestration market, projects must demonstrate sound scientific methods and modeling.

Lacking a detailed analysis of kelp presence in the proposed reintroduction locations, the presence of shallow rocky seafloor can be used as a proxy for the benthic conditions that are necessary for gains in kelp and seagrass coverage. While other environmental conditions affect growth of seagrass and kelp beds, rocky seafloors are a limiting factor and can be used as a proxy indicator for carbon offset payment amounts.

It is reasonable to assume that the rocky habitat in each reintroduction location could develop into a healthy kelp forest and understory when the sea otter population goal was attained in 25 years. Increased habitat formation over time converted to carbon storage would be combined with forecasts of carbon prices, and using a justifiable discount rate result in a Net Present Value (NPV) calculation. Such a method could assume that an alternative location's rocky habitat would trend to a full healthy kelp forest and understory when the sea otter population goal was attained in 25 years. An example NPV calculation concludes that the potential carbon sequestration value of these reintroductions could be:

Yaquina Bay/Otter Rock	$1.3 million
Cape Arago/Coos Bay	$0.3 million
Pt. Orford/Cape Blanco	$1.4 million
Rogue Reef/Crook Point	$1.0 million

Improved carbon sequestration due to sea otter presence will continue after the population goal is reached, but the value will grow more slowly as time goes on.

[10] Wilmers et al. 2012, Gregr et al. 2020a, and Baley et al. 2021.

Increasing Fish Populations

Kelp forests and seagrass beds have other positive effects on coastal marine ecosystems. Science has shown kelp forests contribute to the juvenile survival and reproductive success of market fish species by providing shelter and supporting fish prey (Reisewitz et al.). Other market species, including juvenile salmon, occupy kelp forests. Kelp forest habitat helps attenuate waves and currents, retarding shoreline erosion. Whales feed on zooplankton and fish that occupy kelp forests, and their presence close to shore could promote increased tourism.

Kelp forests are important for the recycling of nutrients such as nitrogen and phosphorus, which can decrease the severity and extent of ocean acidification and hypoxia (Kessouri et al. 2021). Cultivated kelp, or surpluses of wild kelp, can be used in commercial products like cosmetics, paper, and biofuel. It would be helpful to develop a full economic analysis that includes these other indirect ecosystem benefits.

Several academic studies explore the relationship between kelp forest habitat and fisheries, including Tegner and Dayton (2000). However, Davis et al. (2019) concludes "research is needed to quantify the strength and persistence of sea otters' effects on other species targeted by finfish fisheries, to identify the relevant timescale over which changes may be anticipated after sea otters recolonize an area, and to link these changes to fisheries production."

Potential Changes in Fisheries Harvest Value from Sea Otter Reintroduction

Despite these cautions, we provide an estimate, below, of the change in harvest value in commercial nearshore groundfish fisheries. Commercial nearshore groundfish fisheries include such species as black and blue rockfish, greenlings, cabezon, and lingcod that inhabit nearshore nursery areas during some of their lifecycle and are also fished seaward of the nearshore boundary (approximately 30-45 fathoms).

The calculation assumes the following:

- A sustainable population of at least 200 sea otters in a scenario area leads to a long-term kelp restoration;
- An increase in kelp forests leads to increased groundfish production;
- Fishery management allows commercial cumulative quotas and bag limits to increase as a result of an increase in groundfish production, resulting in increased commercial catch;
- Commercial prices are regional and do not change with increased catch;
- Based on Gregr et al. (2020b), the economic investigation estimates that biomass for lingcod and demersal fish fisheries would increase by 3.01 times and 1.47 times respectively.

The ODFW spatial model was used to determine changing harvest value in the reintroduction locations. The model assumes nearshore groundfish fisheries take place within a 30-fm depth contour, which is approximately the same as the boundary between Oregon state waters and the Exclusive Economic Zone.

The potential annual gains predicted to commercial nearshore groundfish harvest value for the reintroduction alternative scenario locations are:

Yaquina Bay/Otter Rock	$180,000
Cape Arago/Coos Bay	$78,000
Pt. Orford/Cape Blanco	$389,000

Rogue Reef/Crook Point $321,000

There could be additional gains in recreational spending for groundfish fishing if a higher success rate from increased groundfish abundance creates an incentive for more fishing trips.

Existence Values

In addition to the market values of fisheries and tourism, a reintroduced sea otter population also has an "existence value." Existence values can represent an immediate value (otters are here now) or a future value (I will see otters on my spring vacation; otters will be here for my grandchildren). The threatened and endangered status of a species heightens their value, and the existence of such a species in an area heightens the existence value of that area (and sometimes its property value as well).

Existence values are often used in policy decision-making. For example, the U.S. Fish and Wildlife Service has included such estimates in a wolf recovery program, and the National Park Service included such values in the environmental impact statement for removal of the Elwha Dam. People can be compensated for the loss of existence values related to damages to natural resources (Unsworth and Petersen 1995).

Properly determined existence values are considered "net economic benefits," and can be compared to net economic benefits from economic activity such as fisheries/aquaculture and tourism.

When expensive surveys are not possible, benefit transfer techniques can be used to determine existence values. Using this technique, the value of a resource in one area is transferred to another similar area. Although this method is not as accurate as a well-conducted study, it can provide useful estimates.

Loomis (2005) studied the non-market valuation of sea otters on the Santa Barbara coast. The study found that a gain of approximately two hundred sea otters was worth $1.83 per California household per year which would be $2.32 in 2019 dollars.

The total non-market value depends on the number of households benefiting from the reintroduction, as well as the time period necessary for developing a sustainable population. There were 1.6 million households in Oregon in 2019. Based on a benefit transfer analysis, the total Oregon value for the existence of 200 sea otters would be $3.7 million annually. Since southern and northern sea otter subpopulations are Federally protected under the Endangered Species Act, it could be argued that *all* U.S. households should be used in the calculation. However, studies have shown that willingness-to-pay decreases with increasing distance from the protection sites (Loomis 2000).

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