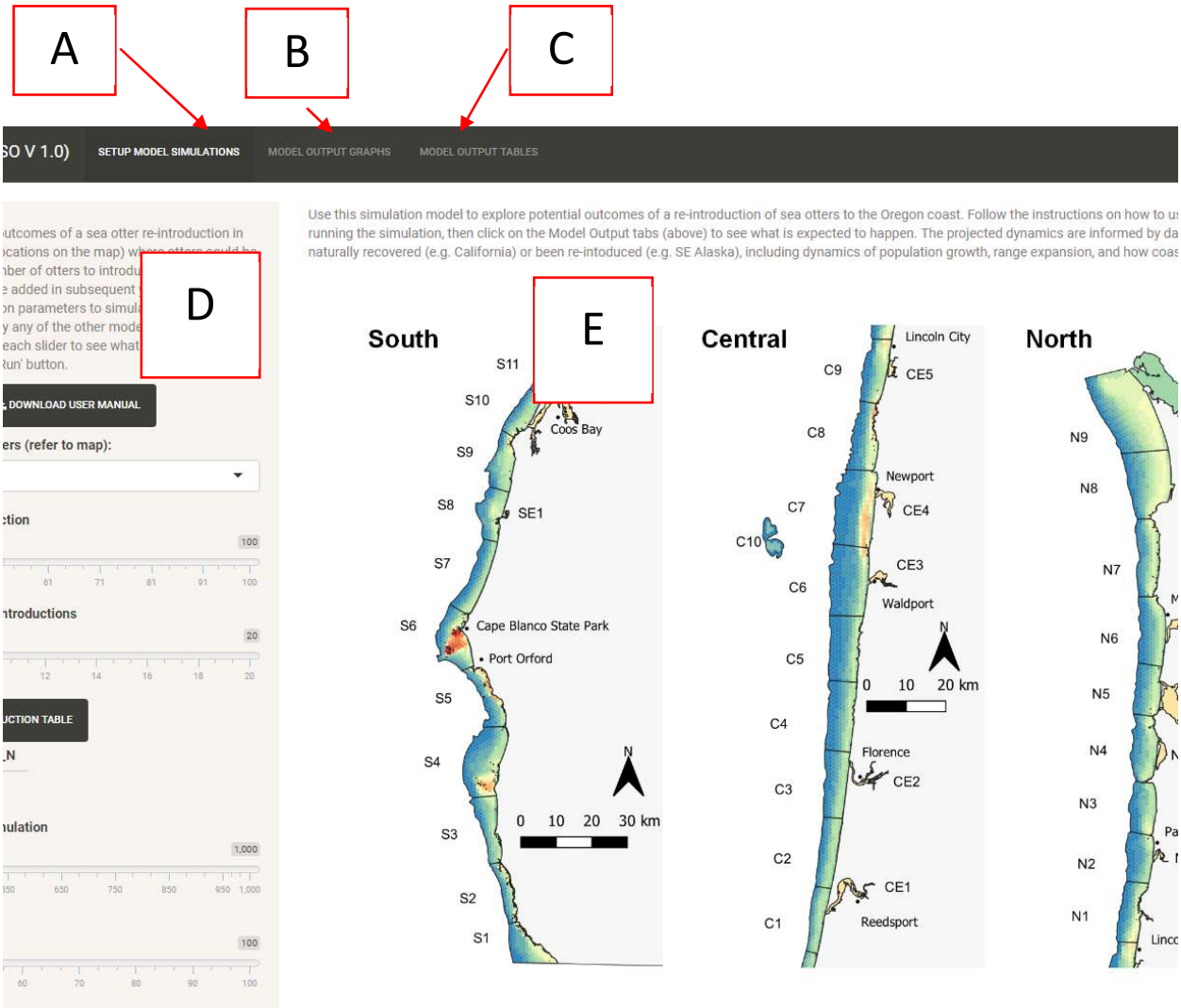
Oregon Sea Otter Population Model (ORSO), User Interface

https://nhydra.shinyapps.io/ORSO_app/

Overview

The web based ORSO app is organized into several panels, which the user can navigate between by clicking on any of the three selection tabs embedded in the title bar at the top of the screen, as shown in the Figure below (items A, B and C). The panel that is active by default when the app is opened is "SETUP MODEL SIMULATIONS", while the other two panels ("MODEL OUTPUT GRAPHS" and "MODEL OUTPUT TABLES") can be navigated to by the user to view model results AFTER having run simulations.

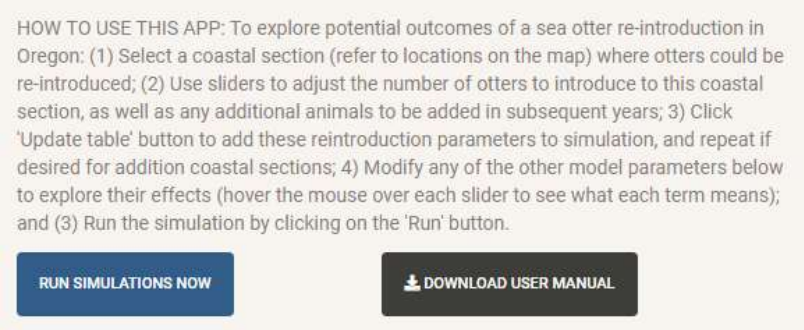
When active, the "SETUP MODEL SIMULATIONS" panel is itself divided into two main sections: a sidebar panel at left (item D) where the user can adjust various parameters and run the simulations; and an information panel at right (item E), which shows a map of Oregon with coastal sea otter habitat (the nearshore zone out to 60 m of depth, plus estuaries) divided into 42 numbered coastal sections. These coastal sections represent the main spatial units for tracking sea otter abundance and distribution over time: the map allows the user to see the location of specific sections, as needed to initiate simulations and interpret model results.



Components of ORSO App

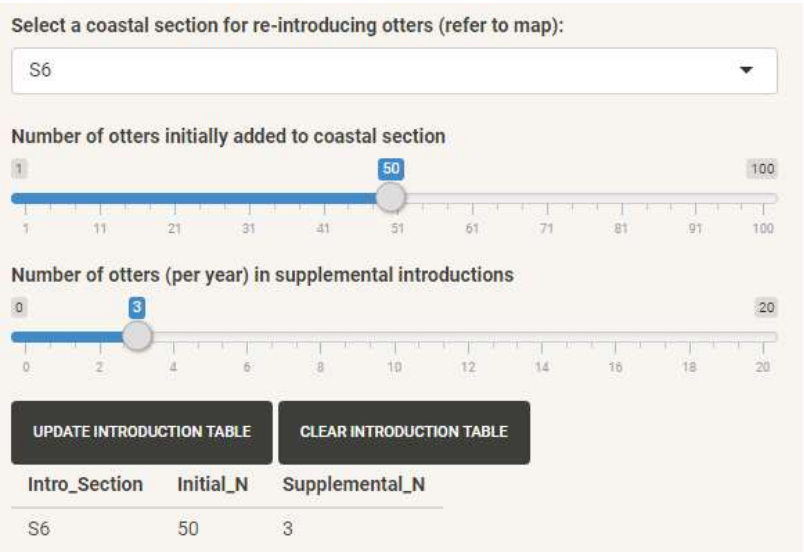
Setup Model Simulations Panel

At the top left of the sidebar panel are some simple instructions to guide the user, and two large buttons: “Run Simulations Now” and “Download User Manual”.



The “Download User Manual” button at right allows the user to download this manual at any time. The “Run Simulations Now” button at left is the primary action button of ORSO, used to run a set of simulations. HOWEVER, this button should only be clicked AFTER having first selected one or more coastal sections under consideration for a sea otter re-introduction and setting the user-adjustable parameters in the sidebar panel that describe the details of the reintroduction and control the underlying assumptions about the nature of population growth and range expansion. A description of each of the user-adjustable parameters will appear when the cursor is moved over top of the name of each parameter, and default values for each parameter are set based on data from other sea otter populations. These user-parameter adjustment controls are illustrated and explained below:

Select coastal sections for reintroduction and numbers of otters to be added



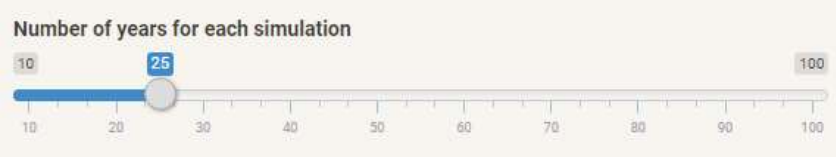
Clicking on the selection box at top reveals a drop-down list of the 42 coastal sections (whose geographic locations can be viewed on the map at right), from which the user can select a coastal section where sea otters are to be introduced. Next, the two sliders below the selection box can be used to adjust the number of otters in the initial translocation event, as well as (optionally) the annual number of animals added to this section as part of supplementary introductions in subsequent years. Clicking on the “Update Introduction Table” button will add these user selections to a parameter table

below the button. The user can then repeat this process (if desired) to specify additional coastal sections and associated translocation parameters and add those to the parameter table. To clear the table and start again at any time, click on the “Clear Introduction Table” button.

Adjust number of iterations

This slider control is used to increase or decrease the number of simulation iterations: that is, the number of times a population simulation is replicated with random draws of all appropriate stochastic parameters. Increasing the number of replications of a simulation improves the precision of model predictions but will take longer to run. At least 100 iterations are suggested.

Adjust number of years

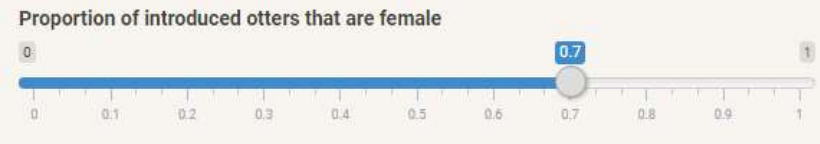


This slider control is used to increase or decrease the number of years into the future the simulation is run. Increasing the number of years ('N') can provide insights into conditions farther in the future, but results become less reliable the farther ahead in time the model is projected.

Adjust number of years that supplemental introductions occur

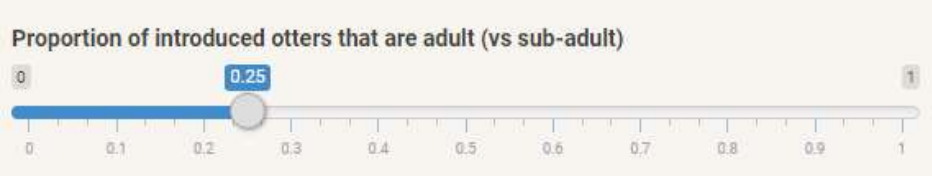
This slider control is used to increase or decrease the number of years after the initial translocation event in which additional otters may be added to the initial reintroduction site (supplemental reintroductions). Adding more otters could potentially improve success of the reintroduction by stabilizing the population during the establishment phase. These additional otters could be wild otters or juvenile re-habilitated otters from captivity.

Adjust sex ratio of reintroduced otters



This slider control allows the user to specify the proportion of introduced otters that are female. Including a higher proportion of females can increase the potential for growth, though there must be at least some adult males for reproduction to occur.

Adjust age composition of reintroduced otters



This slider control allows the user to specify the proportion of introduced otters that are adult (vs sub-adult or juvenile). Only adult sea otters produce pups, so introducing adults can hasten reproduction. However, in past translocations it has been found that sub-adults may be more likely to successfully 'take' to their new habitat, so a higher ratio of sub-adults may improve success.

Adjust duration of "population establishment" phase

Newly established sea otter populations often experience an initial period of reduced growth and limited range expansion, as the population becomes established. This establishment period has varied from 5-15 years in previous re-introductions and natural return events. This slider control allows the user to set the expected duration of this phase. In addition to reduced survival rates and range expansion during the establishment period, the user can specify the probability of post-introduction dispersal away from the release site.

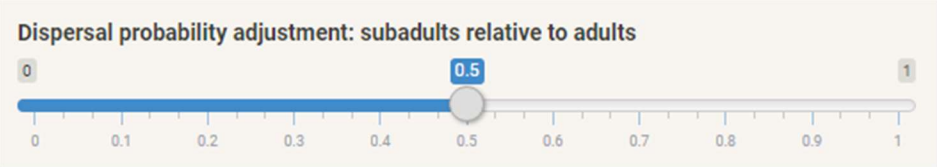
Adjust excess mortality during establishment

During the establishment phase of an introduced population, there may be higher than average levels of mortality as the introduced animals become accustomed to their new habitat. In past translocations, excess annual mortality rates of 0.1 - 0.25 have caused translocated populations to decline substantially during the establishment phase

Adjust probability of dispersal during establishment phase (adults)

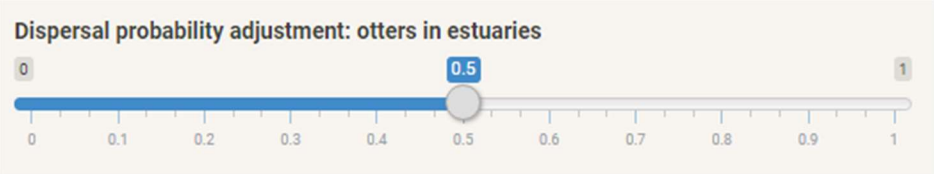
In several previous sea otter translocations, a substantial proportion of the introduced animals moved a significant distance away from the introduction site during the establishment phase. The details and destination of post-release dispersal is impossible to predict, but the user can set the mean expected proportion of otters to disperse.

Adjust probability of dispersal during establishment phase for subadults



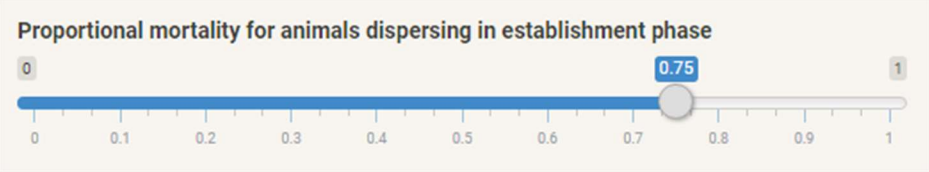
In previous sea otter translocations, it has been observed that subadult animals may be less likely to disperse than adults (i.e. more likely to remain near the introduction site). This parameter adjusts the likelihood of dispersal for subadults as compared to adults: a value of 0.25 would mean that subadults are 1/4 as likely to disperse as adults.

Adjust probability of dispersal during establishment phase for otters in estuaries



Based on several lines of evidence it has been suggested that otters re-introduced to estuaries may be less likely to disperse (i.e. more likely to remain near release sites) than otters added to outer coast habitats. This parameter adjusts the likelihood of dispersal for estuaries as compared to open coast: a value of 0.25 means otters in estuaries are 1/4 as likely to disperse post-introduction.

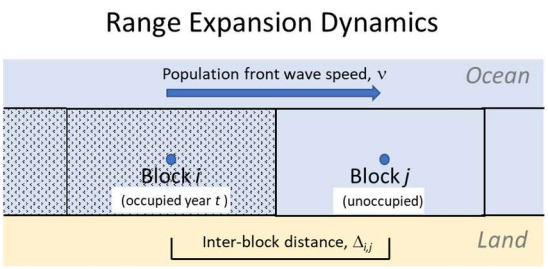
Adjust mortality rate of otters that disperse during establishment phase



The fates of otters that disperse away from a re-introduction sites is hard to determine in most cases: in some reintroductions there appears to have been high levels of mortality for dispersers, in others there is emigration to a different region altogether. This parameter sets the expected loss-rate for the dispersers: that is, the proportion that die or move entirely out of the study area (and are effectively lost to the Oregon meta-population).

Adjust rate of range expansion

This slider control allows the user to adjust the expected rate at which the growing population spreads into new habitat. Distribution of the initial sea otter population will likely be limited to a relatively small area(s) of the coast where sea otters are introduced. As the population grows it's distribution (range of occupancy) will spread outwards along the coastline, encompassing more habitat. The rate of range expansion is measured as the speed at which the frontal edge of the population moves along the coastline (Figure 3). In other populations, this range expansion speed has varied from 1 to 5 km/year.



Schematic drawing illustrating how the model incorporates range expansion of sea otter population from occupied habitat into adjacent unoccupied habitat

Adjust maximum rate of growth

Sea otter populations tend to show the highest rate of growth at low densities: as local abundance increases, the growth rate slows until it eventually reaches 0 when population abundance reaches carrying capacity, or '*K*'. This slider control allows the user to adjust the maximum rate of growth (at low densities): in most sea otter populations this value is between 0.15 and 0.20.

Adjust environmental stochasticity

The average rate of growth for a re-establishing sea otter population in a given area can be predicted as a function of the local density with respect to carrying capacity, or '*K*'. However, year-to-year variation in environmental conditions and prey population dynamics can lead to unpredictable deviations in growth rate, referred to as 'environmental stochasticity'. This slider control can be used to adjust the degree of annual variation in growth rates: typical values are 0.05 - 0.15.

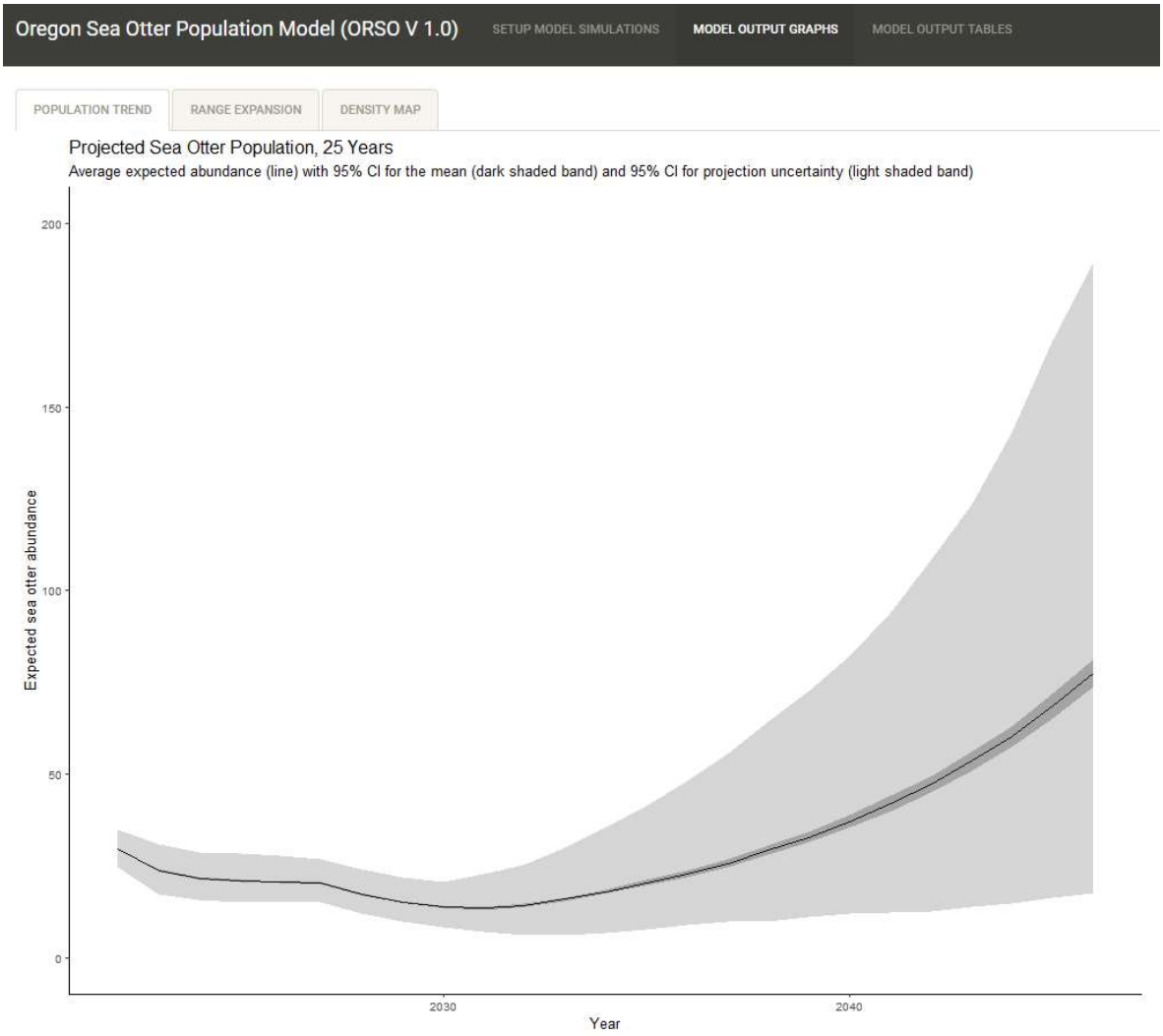
Adjust 'theta' parameter, for theta-logistic growth

The average rate of growth for a re-establishing sea otter population in a given area can be predicted as a function of the local density with respect to carrying capacity, or '*K*'. One of the parameters of this function is 'theta', which determines the nature of the onset of reduced growth rates at higher densities: 'theta' values <1 lead to onset of reduced growth rates at fairly low densities, while 'theta' values >1 mean that significant reductions in growth occur only at higher densities. This slider control can be used to adjust 'theta': typical values reported for marine mammals are between 0.8 and 2, and a recent study in California reported a value of close to 0.9 for southern sea otters.

MODEL OUTPUT GRAPHS Panel

After setting up and running simulations, the user can navigate to the "MODEL OUTPUT GRAPHS" panel in order to view graphical results from model simulations. There are three separate graphs that can be viewed, and the user can move between these by selecting one of the three graph selection tabs just below the title bar.

Population Trend Graph

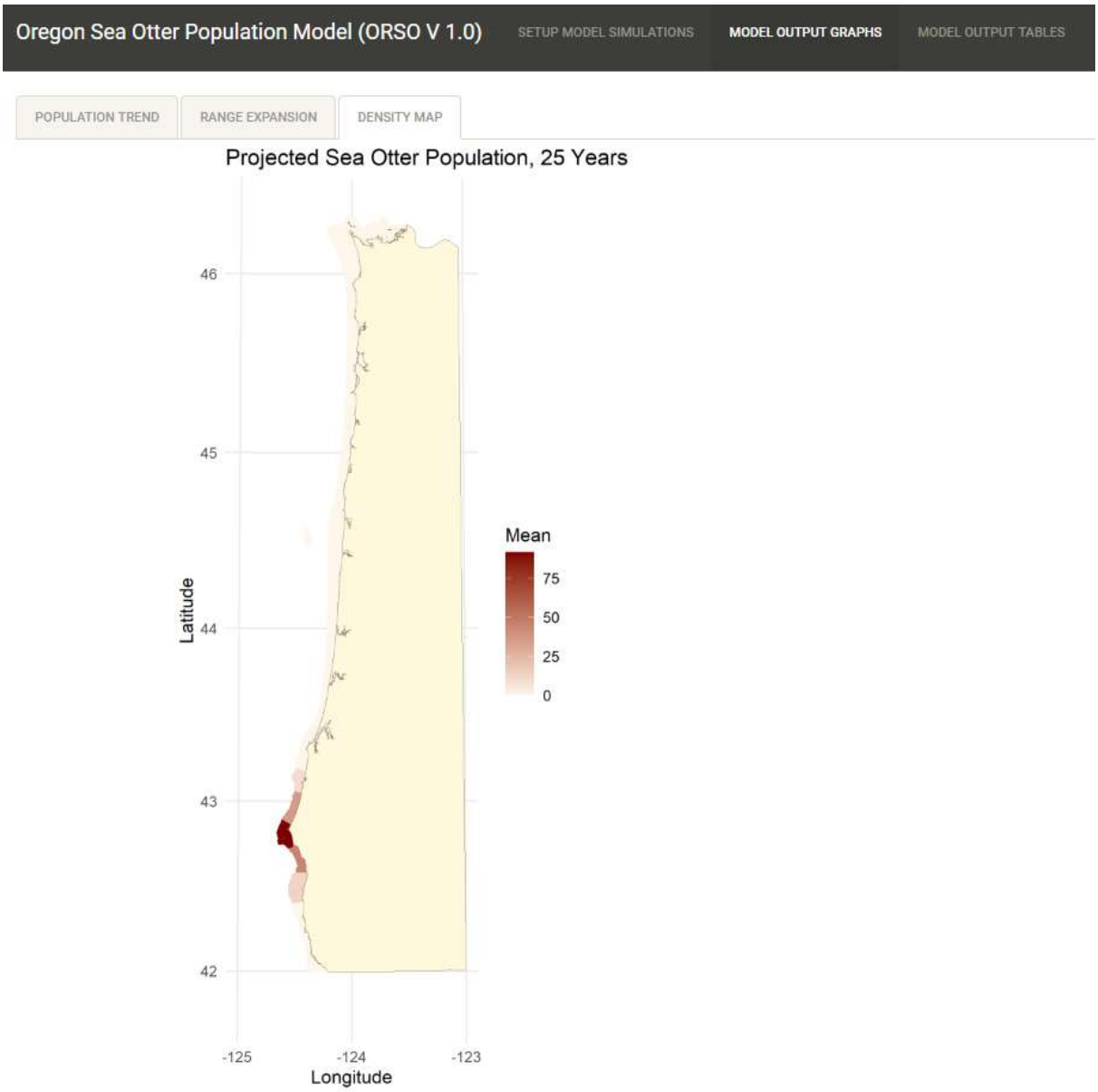


This plot shows the projected abundance over time of sea otters in Oregon, based on results from the simulation model (EXAMPLE SHOWN IS FOR ILLUSTRATIVE PURPOSES ONLY). The horizontal axis represents years into the future, while the vertical axis represents the expected total number of sea otters in a given year. Uncertainty about model results is calculated based on the distribution of results from stochastic iterations of the simulation. The solid black line represents the average abundance trend (i.e. averaged across all iterations), the dark grey band shows the 95% CI for the mean trend (i.e. uncertainty about the true average), and the light grey band shows the 95% CI for the full distribution of results (i.e. uncertainty about the range of possible outcomes).

Range Expansion Graph

This heatmap graph shows the average projected abundance and spatial distribution of sea otters over time (EXAMPLE SHOWN IS FOR ILLUSTRATIVE PURPOSES ONLY). Each grid cell represents a coastal section (vertical axis), as defined by the map on the front page, on a given year (horizontal axis): the shading of the grid cells indicating the relative abundance of sea otters (darker colors = more otters, white cells = no otters). The increase from left-to-right in the number and intensity of shaded cells illustrates the spatiotemporal patterns of range expansion. At the left-hand side of the heatmap (year 1), the spatial distribution is constrained by the starting conditions (density = 0 at all but the section(s) where sea otters are introduced). As one moves from left to right across the heatmap (i.e. moving forward through time), the changes in density and distribution reflect the rates of population growth and range expansion.

Density Map



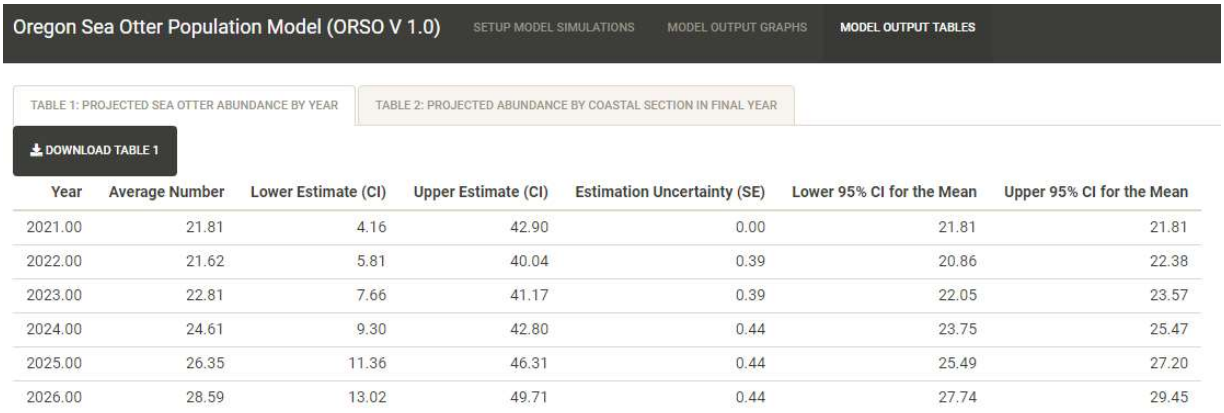
This map figure of coastal Oregon shows the average projected abundance and distribution of sea otters at the end of the simulation period (EXAMPLE SHOWN IS FOR ILLUSTRATIVE PURPOSES ONLY). The mean expected number of sea otters in each coastal section (for the specified reintroduction scenario) is illustrated by the shading of the nearshore habitat zone, with darker shades of red-brown indicating higher abundances of sea otters.

MODEL OUTPUT TABLES Panel

The results of the simulation model can also be viewed in tabular form. After setting up and running simulations, the user can navigate to "MODEL OUTPUT TABLES" panel, where two standardized tables can be viewed and/or downloaded as *.csv files:

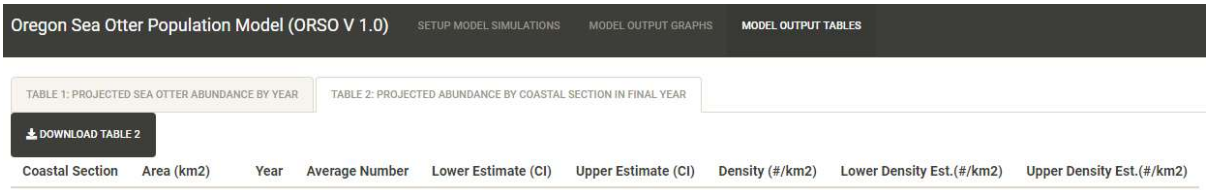
"Table 1: Projected Sea Otter Abundance by Year"

"Table 2: Projected Abundance by Coastal Section in Final Year".



Year	Average Number	Lower Estimate (CI)	Upper Estimate (CI)	Estimation Uncertainty (SE)	Lower 95% CI for the Mean	Upper 95% CI for the Mean
2021.00	21.81	4.16	42.90	0.00	21.81	21.81
2022.00	21.62	5.81	40.04	0.39	20.86	22.38
2023.00	22.81	7.66	41.17	0.39	22.05	23.57
2024.00	24.61	9.30	42.80	0.44	23.75	25.47
2025.00	26.35	11.36	46.31	0.44	25.49	27.20
2026.00	28.59	13.02	49.71	0.44	27.74	29.45

Table 1 summarizes total projected abundance across all of coastal Oregon for each year of the simulation, and includes six metrics: average projected abundance, lower estimate 95% CI of the projected abundance distribution, upper estimate 95% CI of the projected abundance distribution, estimation uncertainty expressed by the standard error (SE) of the mean projected abundance, lower 95% CI for the average expected abundance, and upper 95% CI for the average expected abundance.



Coastal Section	Area (km2)	Year	Average Number	Lower Estimate (CI)	Upper Estimate (CI)	Density (#/km2)	Lower Density Est.(#/km2)	Upper Density Est.(#/km2)
S1	86.97	2045.00	0.09	0.00	0.00	0.00	0.00	0.00
S2	55.32	2045.00	0.10	0.00	0.00	0.00	0.00	0.00
S3	90.69	2045.00	0.09	0.00	0.00	0.00	0.00	0.00
S4	181.74	2045.00	13.11	0.00	30.00	0.07	0.00	0.17
S5	82.00	2045.00	44.95	13.00	94.00	0.54	0.16	1.15
S6	123.91	2045.00	91.54	29.00	191.00	0.73	0.23	1.54
S7	100.98	2045.00	35.90	10.00	72.00	0.35	0.10	0.71
S8	87.37	2045.00	9.51	0.00	23.00	0.11	0.00	0.26
S9	88.00	2045.00	0.54	0.00	4.00	0.00	0.00	0.05
S10	71.63	2045.00	0.23	0.00	0.00	0.00	0.00	0.00

Table 2 summarizes the projected abundance and density in each coastal section on the final year of the simulation: columns include area of benthic habitat in each section (km2), average projected number of sea otters, lower estimate 95% CI of the projected abundance distribution, upper estimate 95% CI of the projected abundance distribution, average density (number of sea otters/km2), lower 95% CI of the projected density distribution, upper 95% CI of the projected density distribution.

In addition to viewing the tables, they can also be downloaded as csv files by clicking on the download buttons above each table.