BEFORE THE UNITED STATES DEPARTMENT OF THE INTERIOR
AND THE UNITED STATES FISH AND WILDLIFE SERVICE

In the Matter of the Removal of the
Southern Sea Otter from the List of
Threatened Species or, in the alternative,
for a Rule Under Section 4(d) of the
Endangered Species Act

Petition of the California Sea Urchin Commission and Pacific Legal Foundation for the Removal of the Southern Sea Otter From the List of Threatened Species or, in the Alternative, for a Rule Under Section 4(d) of the Endangered Species Act

---

DAMIEN M. SCHIFF
Pacific Legal Foundation
555 Capitol Mall, Suite 1290
Sacramento, CA 95814
Telephone: (916) 419–7111
DSchiff@pacificlegal.org

PAIGE E. GILLIARD
NATHAN W. HOTES
Pacific Legal Foundation
3100 Clarendon Blvd., Suite 1000
Arlington, Virginia 22201
Telephone: (202) 888-6881
PGilliard@pacificlegal.org
NHotes@pacificlegal.org

Counsel for Petitioners California Sea Urchin Commission and Pacific Legal Foundation

Table of Contents

Introduction

Pursuant to 16 U.S.C. § 1533(b)(3) and 50 C.F.R. § 424.14(a), Petitioners California Sea Urchin Commission and Pacific Legal Foundation ("Petitioners") petition the Secretary of the Department of Interior and the United States Fish and Wildlife Service (the "Service") to delist the Southern sea otter (*Enhydra lutris nereis*) from the list of threatened wildlife, 50 C.F.R. § 17.11(h), under the Endangered Species Act, 16 U.S.C. §§ 1531–1544; 84 Fed. Reg. 45,020 (Aug. 27, 2019). Delisting is warranted because the best available scientific and commercial data, including independent analysis of recent census data,[1] show the Southern sea otter is no longer in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

Most significantly, the threat of a major oil spill within the range of the Southern sea otter has reduced considerably, thanks to regulations enacted since the otter's 1977 listing, new technologies, oil spill preparedness, and evolving market forces. No comparable threat has arisen in the meantime. Moreover, the hypothetical worst-case oil spills and the RCP 8.5 climate scenario, evaluated in the Service's 2023 Species Status Assessment[2] and "not warranted" decision,[3] do not constitute the best available science evaluating the potential threats of oils spills and/or climate change.

Instead of retreating, the otter's range has grown and its population has steadily increased. Annual census data gathered by the United States Geological Survey (the "USGS") through 2025 show that the otter population exceeded the 2003 Recovery Plan's delisting population threshold for most of the past decade.[4] Considering the population's rebound and the reduction of threats to the species, no compelling scientific basis exists to justify the Southern sea otter's continued listing.

Alternatively, the Service should adopt a tailored 4(d) rule for the Southern sea otter to reward stakeholders for their role in the species' recovery to date and encourage continued progress. In particular, the Service should revive the protections Congress afforded fishermen and other oceangoers under Public Law No. 99-625 and extend those binding protections range-wide.

Petitioners

The California Sea Urchin Commission is a California state entity, created to promote sustainable sea urchin harvest, educate consumers and the public about sea urchins, and balance sea urchin harvest with environmental protection. The sea urchin fishery in California is an artisanal dive fishery which primarily targets hand-harvested red sea urchins (*Mesocentrotus franciscanus*). Small boats with multiple divers make single-day to multi-day trips to harvest the

---

[1] No official census was undertaken in 2020, and the FOIA data sent to Petitioners was titled as survey tables, but Petitioners title the numbers as "census data" for simplicity.

[2] U.S. FISH AND WILDLIFE SERV., SPECIES STATUS ASSESSMENT FOR THE SOUTHERN SEA OTTER (*ENHYDRA LUTRIS NEREIS*) (2023).

[3] 88 Fed. Reg. 64,870, 64,880 (Sep. 20, 2023).

[4] 68 C.F.R. § 16305 (2003).

sea urchins. Fishermen ship harvested sea urchins live to processing facilities, and the urchins are then sold domestically or exported.

Sea otters voraciously consume sea urchins, depleting their stock and frustrating sustainable harvest efforts. Regulations resulting from the sea otter's listing also interfere with sustainable harvest by exposing urchin divers to significant criminal and civil penalties should their activities disturb an otter. For this reason, Petitioners support solutions that promote the sea otter's recovery while protecting fishermen from unfair regulatory burdens and California's sea urchin stock from unmanaged predation.

Pacific Legal Foundation (PLF) is the nation's oldest nonprofit legal organization that fights to protect private property rights and other constitutional liberties in courts nationwide, particularly when wrongheaded environmental regulation threatens these legal principles. PLF attorneys have served as counsel of record in many Endangered Species Act (ESA) cases.[5] PLF has also written extensively on the ESA.[6]

Timeline of Recent Events

On March 10, 2021, Pacific Legal Foundation filed a **delisting petition** for the Southern sea otter with the Service on behalf of the California Sea Urchin Commission (hereafter "Commission") and the Commercial Fishermen of Santa Barbara.[7]

On August 23, 2022, the Service published a **90-day finding**[8] that the petition presented substantial scientific or commercial information indicating that delisting the Southern sea otter may be warranted.

On September 14, 2023, Petitioners provided an update to the Service containing additional scientific and commercial information (hereafter, "**Science Update**").[9]

On June 27, 2023, the Service finalized its **Species Status Assessment**. On September 21, 2023, the Service posted it online.[10]

On September 20, 2023, the Service issued its **one-year finding on the Petition that delisting was not warranted**.[11]

---

[5] *See* Weyerhaeuser Co. v. U.S. Fish & Wildlife Serv., 586 U.S. 9 (2018); Skipper v. U.S. Fish & Wildlife Serv., 796 F. Supp. 3d 996 (S.D. Ala. 2025); Kan. Nat. Res. Coal. v. U.S. Fish & Wildlife Serv., 780 F. Supp. 3d 650 (W.D. Tex. 2025).

[6] *See* Mitchell Scacchi, *Intrastate Species Under the Endangered Species Act* (Pacific Legal Found., 2025), bit.ly/48wzwj3; Chales Yates, *Government should stop redefining 'take' in Endangered Species Act enforcement* (Pacific Legal Found., 2025), https://bit.ly/46jqZie.

[7] 88 Fed. Reg. 64,870.

[8] 87 Fed. Reg. 51,635 (Aug. 23, 2022).

[9] 88 Fed. Reg. at 64,870.

[10] U.S. FISH AND WILDLIFE SERV., SPECIES STATUS ASSESSMENT FOR THE SOUTHERN SEA OTTER (*ENHYDRA LUTRIS NEREIS*) (2023).

[11] 88 Fed. Reg. 64,870.

Overview

Petitioners present new data and information on Southern sea otter population size, trends, and threats, along with critical reanalyses of existing data and information not previously considered by the Service. Petitioners analyze new Southern sea otter data obtained from the USGS via recent Freedom of Information Act (FOIA) requests. Petitioners then provide new, critical reanalysis of an unpublished oil spill and climate change impact study that relied on hypothetical, worst-case scenarios for oil spills and climate change, along with inaccurate information used by the Service in its modeling assumptions.[12] That study was central to both the Service's 2023 Species Status Assessment and the Service's 2023 "not warranted" delisting decision.

Petitioners also provide updated data and information, originally submitted to the Service in the 2021 Petition, that was ignored in the Service's 2023 Species Status Assessment ("SSA") and the Service's "not warranted for delisting" decision. Additionally, those documents failed to mention Petitioners' proposed alternative to delisting: adopting a tailored 4(d) rule that would revive protections that Congress afforded fishermen and other oceangoers under Public Law No. 99-625. Petitioners repeat that request in Section III, and expand it to ask that the protections be extended range-wide due to the Southern sea otters' recovery.

Additionally, Petitioners supplied updated data and scientific information, originally sent to the Service on September 14, 2023, that were not considered by the Service in its 09.20.23 one-year finding. Petitioner's "09.14.2023 Science Update" was received by the Service shortly before online publication of the "not warranted" decision in the Federal Register. However, the "not warranted" decision did not address any of the 09.14.2023 Science Update's points. This omission is significant because the 09.14.2023 Science Update refutes the genetic and demographic rationale used to raise the demographic thresholds for delisting criteria in the 2023 Species Status Assessment ("2023 SSA").[13]

Petitioners request that all data and information in this petition, including updated information from the 2021 petition and the 09.14.2023 Science Update, be fully considered by the Service as it did not consider them previously. Petitioners identify where these updated sections are used.

Finally, Petitioners provide new data, information, and reasoning why Southern sea otters should be allowed to recolonize areas naturally but otherwise should not be translocated to the coast of Northern California, San Francisco Bay, and Channel Islands.

Collectively, the analysis of data and other information provided in this petition reveal that the Southern sea otter met its recovery goals and that the primary threats to it were successfully

---

[12] Tinker MT. 2021. Incorporating Oil Spill Simulations into the Southern Sea Otter Integrated Population Model. Prepared by M. Tim Tinker, Nhydra Ecological Research and Conservation Metrics for U.S. Fish and Wildlife Service. March 2021. Appendix to USFWS 2023. Species Status Assessment for the Southern Sea Otter (Enhydra lutris nereis). U.S. Fish and Wildlife Service, Region 8. Sacramento, CA. 101 pp. + Appendix ("Tinker (2021)").

[13] The 2023 SSA was finalized on June 27, 2023 (based to its file metadata), before the Commission submitted its 09.14.2023 Science Update but only released online on September 21, 2023, *after* the Service's "not Warranted" decision. Therefore, the Commission's Science Update supersedes the information in the 2023 SSA.

mitigated through research and concerted regulatory efforts at the state and federal level. Its recovery is an Endangered Species Act success story. Retaining this subspecies on the list of threatened species is no longer necessary to ensure its continued existence. As described below, the best scientific and commercial data available indicate that the Southern sea otter's continued listing is not warranted under the Endangered Species Act's five factors and that the species should be removed from the threatened species list.

I. The Southern sea otter is no longer a threatened species.

A. The present or threatened destruction, modification, or curtailment of habitat.

When the Service listed the Southern sea otter in 1977, the species' primary threat was its limited range, which made it vulnerable to extinction from a large oil spill. *See* U.S. Fish & Wildlife Service's, *Southern Sea Otter: 5-Year Review* 15-18 (2015) and *Species Status Assessment for the Southern Sea Otter* (*Enhydra lutris nereis*) (2023).

Since 1977, however, the population's occupied range has dramatically increased to over 500 km of Southern California coastline. According to a study by Hughes et al. (2019), available unoccupied habitat could support triple the current population. More recent modeling of habitat carrying capacity and population projections by Tinker et al. (2021a,b) indicate a likely fivefold increase in population size by 2070 (17,226 otters, 95% CI = 9,739–30,087) and a natural range expansion into the San Francisco Bay, the Northern California coast, and through the Channel Islands. Consequently, Southern sea otters are not threatened due to the destruction, modification, or curtailment of habitat. Studies by Tinker et al. (2021a,b) show that there is an abundance of available habitat that will eventually be colonized by Southern sea otters.

Recent USGS census data show that otters have increased in both number and range, albeit slowly and with periodic fluctuations in long-term trends, since systematic counts began in 1983 (Hatfield et al. 2019; USGS census data 2019 to 2025). Furthermore, the sea otter population that translocated to San Nicolas Island, erroneously declared a failure by the Service in 2012, has grown. Consistent with these findings is the lack of data published or in the public domain indicating that the otter's total population or range are threatened by destruction, modification, or curtailment of their habitat, such that this subspecies is likely to be threatened with extinction moving forward.

A.1 The best available scientific data on Southern Sea Otter population size reveal that it has repeatedly surpassed threshold delisting requirements over the past decade, and more trend data reveal that the population has continually increased in number.[14]

Range-wide Southern sea otter count data from both shore and aerial observations along the Southern California Coast and San Nicolas Island were used by the USGS to produce three-year running averages of population abundance until 2018 (Hatfield 2018).[15] Table 1 of the Hatfield 2019 USGS report shows the traditional range-wide population indexes in 2016, 2017, and 2018 all exceeded the 3,090 number required for delisting in the 2003 Recovery Plan.[16] In 2019, the traditional three-year average dipped slightly to 2,962, although 3,117 otters were counted.[17] No census was conducted in 2020 due to COVID.[18] Although counts resumed in 2021, there were substantial gaps in the mainland shore counts and no aerial surveys were conducted during that census due to logistical constraints (primarily due to landslides preventing access to observation sites and aircraft being unavailable).[19]

In 2023, the USGS changed how it calculated the range-wide population index to only include data from shore counts based on the same areas surveyed in the 2021 census in the three-year running averages.[20] This new method was termed the “Modified Range-wide Index.” The USGS subsequently used this method to recalculate an annual Modified Range-wide Index from all count data going back to 1985, but only included data from areas counted during the 2021 census. The idea was to have a consistent index of long-term population trends despite large gaps in sampling imposed by COVID and other factors after 2019. However, otter census data from large areas, both offshore and near-shore, were dropped from the total number of otters annually counted. Thus, while useful for tracking population trends, which have been consistently increasing, the Modified Range-wide Index does not account for all otters counted annually during each census.

---

[14] New data and information, unique to this petition.

[15] https://pubs.usgs.gov/publication/ds1097

[16] 68 C.F.R. § 16305.

[17] U.S. Geological Survey, 2024 Southern Sea Otter Census & Statistical Model Development p. 26 (2024).

[18] *Id.* at 3.

[19] *Id.*

[20] https://www.usgs.gov/centers/werc/news/annual-southern-sea-otter-census-temporarily-modified

In presenting only the Modified Range-wide Index since 2019,[21] USGS has omitted any mention about what actual annual totals have been in recent years. This is especially an issue for all data collected after 2021. That is because censuses from 2022 and later surveyed more shoreline than the 2021 census and added new areas to the north and south of the 2021 census. Of recent censuses, only the 2024 census, discussed below, included both shore and aerial counts. This omission of important data for the Commission and decision makers by the USGS and Service[22] regarding the total number of otters counted annually is significant in two ways. First, one delisting criteria is based upon a three-year average of the total number of otters counted, not the Modified Range-wide Index based on three-year averages *of a subset of the total number of otters counted* (i.e., only from those areas surveyed in 2021). Second, USGS staff have only presented Modified Range-wide Index results from 2021 (~2,800 otters), 2022 (3,115 otters), and 2023 (3,028 otters) to the Commission and at recent conferences without presenting the total number of otters counted in those and more recent censuses. Thus, the Commission, decision makers at the Department of Interior, and the public appear to have been misinformed about the Southern sea otter crossing its numerical delisting threshold in recent years. Table 1 (below) presents the actual total number of otters counted since 2015 and three-year averages.

---

[21] Online presentation of census results to California Sea Urchin Commission, May 31, 2023.

Southern Sea Otter Census & Statistical Model Development: Results from the Modified California Sea Otter Census 2021 & 2022. Authors: Joe Tomoleoni, Julie Yee, Mike Kenner, Brian Hatfield, Mike Harris, Colleen Young, Jessica Fujii, Teri Nicholson, Gena Bentall, and Lilian Carswell. Presentation given at the March 17th, 2023, Sea Otter Conservation Workshop XIII held at the Seattle Aquarium.

Results from the Modified California Sea Otter Census 2023. Joe Tomoleoni, Julie Yee, Mike Kenner, Brian Hatfield, Mike Harris, Colleen Young, Jessica Fujii, Teri Nicholson, Gena Bentall, and Lilian Carswell. Presentation given at the Southern Sea Otter Research Update Meeting (SSORUM), March 7–8, 2024 at the Hilton Santa Cruz/Scotts Valley.

[22] FOIA: DOI-2025-008251: In response to FOIA requests, the Service directed us to USGS for the census data. Service staff are co-authors of the presentations discussed above.

Table 1. Total number of Southern sea otters observed during annual counts and three-year averages of census data.[23] These numbers include all otters counted, not just those within the same areas counted in 2021 (as used in the "Modified Range-wide Index"). The 2016 to 2018 census data are from the USGS report by Hatfield et al. (2019).[24] That report combined mainland shore and offshore aerial counts into one column. Census results for later years were supplied by USGS in response to FOIA requests by the Pacific Legal Foundation.[25] There was no census in 2020 due to COVID restrictions. The three-year averages in 2022, 2023, and 2025 exceeded the delisting threshold, even *without* aerial counts.

Year	**Mainland Shore**	**Offshore Aerial**	**Mainland shore + offshore aerial**	**San Nicolas Is.**	**Total Counted**	**3-Year Average[26]**
2016			3,511	104	**3,615**	**3,272**
2017			2,607	81	**2,688**	**3,186**
2018			2,986	95	**3,081**	**3,128**
2019	2,826	170		121	**3,117**	**2,962**
2020	no count	no count		116	**-**	**-**
2021	2,879	no count		157[27]	**3,036**	**3,078**
2022	3,469	no count		121	**3,590**	**3,248**
2023	2,936	no count		146	**3,082**	**3,236**
2024	3,008	220		114	**3,342**	**3,338**
2025	3,080	no count		84	**3,164**	**3,196**

The three-year average of the total number of otters counted has exceeded the delisting threshold for the past four censuses. Additionally, if the 2021, 2022, 2023, or 2025 census had included an aerial count, the totals and three-year averages would have been even higher, well exceeding the delisting threshold.

When viewed in combination with results over the past decade, including the three-year averages from 2016, 2017, and 2018, the delisting threshold was exceeded in seven of nine years. Also,

---

[23] The data collected and reported by the USGS are uncorrected counts. Potential for double counting by the USGS is minimized by utilizing consistent survey sections of the coast and experienced observers. Though not explicitly stated, the methodology implicitly assumes that otters in one section are not counted again in another section on a different day, or between aerial and shore counts.

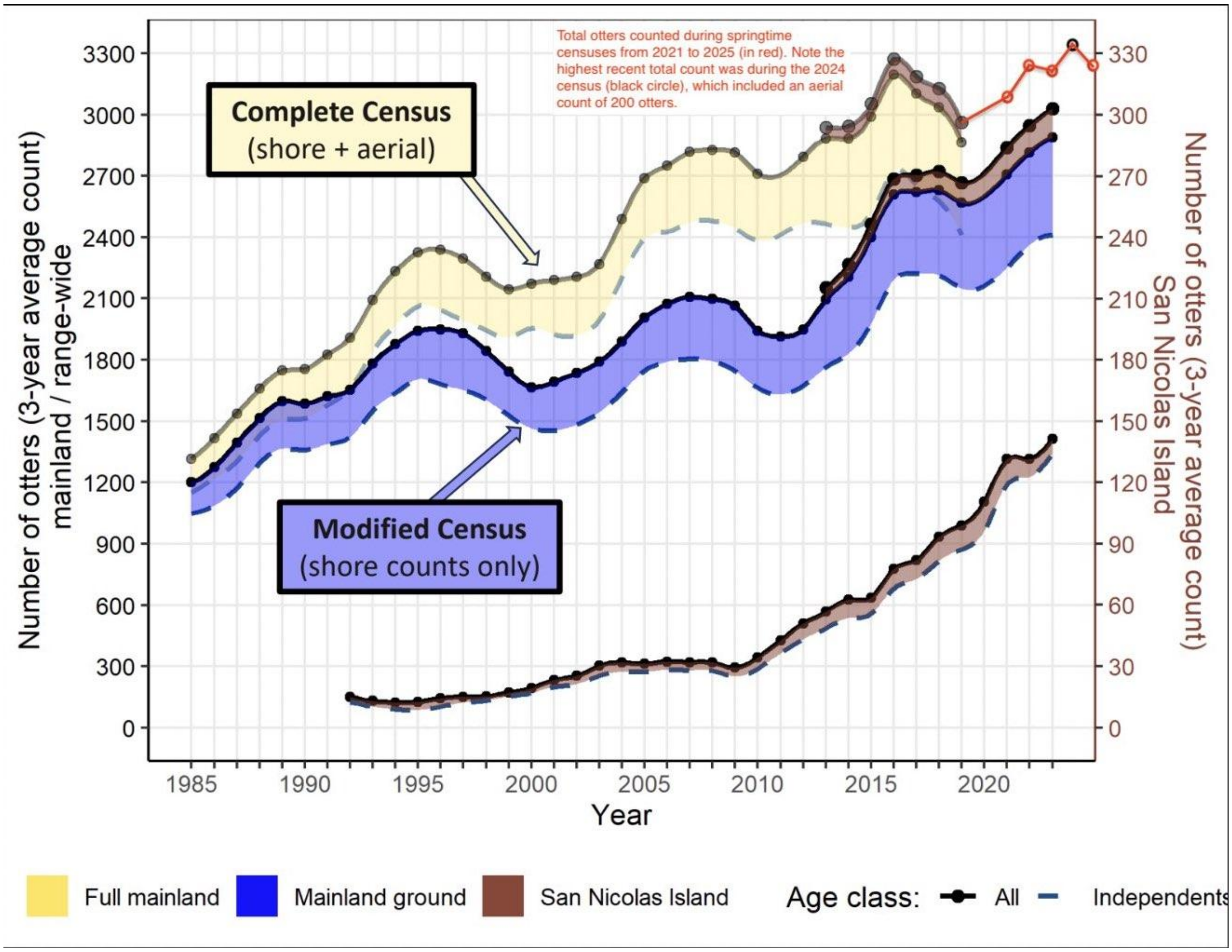
[24] Hatfield, B.B., Yee, J.L., Kenner, M.C., and Tomoleoni, J.A., 2019, California sea otter (*Enhydra lutris nereis*) census results, spring 2019: U.S. Geological Survey Data Series 1118, 12 p., https://doi.org/10.3133/ds1118.

[25] DOI-2025-009106 and DOI-2026-002084.

[26] The three-year running average is the average of the current year and two previous censuses. With the exception of 2024, no aerial census has been carried out since 2019.

[27] Summer count as there was no spring count. Data from Table 2 of Yee, J.L., Tomoleoni, J.A., Kenner, M.C., Fujii, J.A., Bentall, G.B., Staedler, M.M., and Hatfield, B.B. 2023. Southern (California) sea otter population status and trends at San Nicolas Island, 2020–2023: U.S. Geological Survey Open-File Report 2023–1071, 37 p., https://doi.org/10.3133/ofr20231071.

despite a slight dip below the delisting threshold in 2019 (recall, no data were collected in 2020), the population has continued to increase in both number and range (Figure 1).



Total otters counted during springtime censuses from 2021 to 2025 (in red). Note the highest recent total count was during the 2024 census (black circle), which included an aerial count of 200 otters.

Figure 1. Southern sea otter population three-year averages of complete census (total counted) and modified range-wide index. Note how the Modified Range-wide Index is consistently lower than that of a complete census.[28]

Regardless of how counts are totaled or population trends are estimated, results show that the Southern sea otter population has increased, albeit with small population fluctuations, since census data collection began in 1985. USGS predicts its trend will continue as otters naturally colonize new areas.[29]

---

[28] U.S. Geological Survey, 2024 Southern Sea Otter Census & Statistical Model Development p. 7 (2024). Petitioners' addition is added in red.

[29] Tinker MT, Carswell LP, Tomoleoni JA, Hatfield BB, Harris MD, Miller MA, Moriarty ME, Johnson, CK, Young C, Henkel LA, Staedler MM, Miles AK, Yee, JL. 2021a. An integrated population model for southern sea otters: U.S. Geological Survey Open-File Report 2021–1076, 50 p., https://doi.org/10.3133/ofr20211076 ("Tinker 2021b").

A.2) Awaiting development of a new Bayesian model for population estimation is not a reason to delay delisting.

Since 2023, USGS has worked on a Bayesian model to estimate population size even without data from some areas normally counted.[30] While Petitioners find this effort laudable, decision makers must realize that the total counts, discussed with data above, are actually *minimum counts* of the total number of otters in the population and that Bayesian model estimates will be higher (they can account for missing data). However, three years after announcing the Bayesian model development, no such model has been produced and key personnel developing the model have retired. Therefore, using traditional count data even with incomplete sampling is the best available science for decision making. Moreover, because these are *minimum counts*, they are also the most precautionary information for use by decision makers. This becomes apparent when those numbers consistently exceed a delisting threshold.

A.3) New evidence since the prior delisting petition calls the Service's previous rationale into question.

In our analysis (see factor five below, *Other Natural or Man-made Factors Affecting the Population's Continued Existence*), Petitioners present evidence not previously considered by the Service, including updated scientific and commercial data. Petitioners also discuss environmental regulations enacted since the otter's listing that the Service can use to evaluate the threat of catastrophic oil spills. This threat was the primary reason for listing the Southern sea otter as a threatened species in 1977.

Similarly, in our analysis of factor three (see below), Petitioners report on new scientific data, modeling analyses, and insights into the ecology and evolution of the parasite *Toxoplasma gondii*. Those data, analyses, and insights, along with hypotheses consistent with the available scientific data, were not previously considered by the Service in the SAA or their not warranted decision. Extensive research published in peer-reviewed scientific literature since 2020 show that this parasite naturally occurs in the wild and infects virtually every species of mammal. *Toxoplasma gondii*'s presence in the environment from human sources (domestic cats) does not represent destruction or modification of Southern sea otter habitat.

---

[30] https://www.usgs.gov/centers/werc/news/2024-southern-sea-otter-census-and-statistical-model-development, or any more recent Southern sea otter census results.

2024 Southern Sea Otter Census & Statistical Model Development. Joe Tomoleoni, Julie Yee, Mike Kenner, Brian Hatfield, Michelle Staedler, Mike Harris, Colleen Young, Laird Henkel, Jessica Fujii, Teri Nicholson, Gena Bentall, Lilian Carswell, Tim Tinker. Presentation given at Sea Otter Conservation Workshop XIV, March 21–23, 2025, held at the Seattle Aquarium.

A.4) Population trend analyses, based upon best available scientific data, reveal that the Southern sea otter population is highly likely to continue to expand both in number and range within the foreseeable future (i.e., within projected 95% confidence intervals). This population expansion is projected whether or not translocations are undertaken, and whether or not shark-bite mortality decreases from levels used in population modeling by Tinker et al. (2021a).[31]

A.4.1) Tinker et al. (2021a) USGS open file report: *An integrated population model for Southern sea otters.*

Tinker et al. (2021a) presented results that utilized an integrated population model (IPM) to model potential trajectories of the Southern sea otter from 2021 to 2070: "Forward simulations of population dynamics using the IPM results indicate an expectation of continued slow positive growth of the Southern sea otter meta-population during the next 50 years (N_{50}=4,563 versus N_1=2,962), although the range of uncertainty in model projections (95-percent CI=2,267–7,278) also includes the potential for negative growth (fig. 8)." When Tinker et al. (2021a) relaxed their confidence intervals to 80% to include more marginal results—and therefore a wider range of less likely projections—they reported: "the mean projected trend corresponded to a 54-percent increase in abundance after 50 years, but the 80-percent CI included projections ranging from a 23-percent decline to 146-percent increase." While long-term population decline is possible, Tinker et al. (2021a) found it unlikely compared to an ongoing population increase. The data demonstrate that a population increase of Southern sea otters is highly likely to continue moving forward.

Tinker et al. (2021a) also predicted that Southern sea otters will have naturally colonized Santa Barbara's southern coast (areas SB and S1 in Figure 1 of that study), Channel Islands (C1), Half Moon Bay (HB), and San Francisco Bay (SF) by 2050, with a mean population predicted to be approximately 3,500 under their baseline scenario (see Figures 8a, 8b and 9 of Tinker et al. 2021a). Under a 20% lower shark bite scenario, the mean could be approximately 7,500 otters by 2070. Reintroductions would likely accelerate these trends, as shown in Figure 11 (the proportional change in simulated expected abundance after 50 years with reintroductions relative to no reintroductions). Figure 12 illustrates a spatiotemporal heatmap showing projected population growth in each coastal area over fifty years, from 2021 to 2070. However, reintroductions are clearly not currently necessary to achieve recovery, as that threshold of 3,090 averaged over three years has already been passed multiple times over the past decade (Table 1).

As noted by Tinker et al. (2021a), the IPM model used in their analyses relied on multiple independent sources of data on Southern sea otters gathered in the field from 1983 to 2018. Tinker et al. (2021a) describes the advantages of a data driven modeling approach:

---

[31] Tinker MT, Carswell LP, Tomoleoni JA, Hatfield BB, Harris MD, Miller MA, Moriarty ME, Johnson, CK, Young C, Henkel LA, Staedler MM, Miles AK, Yee, JL. 2021a. An integrated population model for southern sea otters: U.S. Geological Survey Open-File Report 2021–1076, 50 p., https://doi.org/10.3133/ofr20211076 ("Tinker 2021(a)"). Updated data and information, from Petitioners' 09.14.2023 Science Update.

> What distinguishes an IPM from a more conventional population model is that the model parameters are fit to multiple independent (or semi-independent) data sources, such as survey data and mark-recapture survival data (Abadi and others, 2010; Tempel and others, 2014). The result is a more comprehensive and, in many cases, more robust population model that can be used to examine causes of decline, measure population-level impacts of specific threats, explore spatial patterns and metapopulation dynamics, and compare the likely efficacy of alternative management strategies (Rhodes and others, 2011; Chandler and Clark, 2014; Zipkin and Saunders, 2018).

The robustness of the Tinker et al. (2021a) integrated population model provides high confidence that the Southern sea otter population will continue to expand going forward, colonizing additional areas of the California Coast including the San Francisco Bay and Channel Islands. Although sea otter colonization along the coast has been described as "slow," it has been quantified based on credible, systematically-collected data analyzed by Tinker et al. (2021a) (i.e., 3.7 kilometers per year (km/yr) south and 2.9 km/yr north). Taken collectively, the data and analyses of Tinker et al. (2021a,b) indicate a consistent positive trend of population increase and range expansion, with or without reintroduction.

Although some authors have conjectured that northward population expansion has stagnated beyond Año Nuevo State Park due to the risk of sharks and/or limited food resources (Lyon et al. 2024),[32] the northern extent of the range is considered to be Half Moon Bay (i.e., Pillar Point/Mavericks) as otters have been observed there and even farther north.[33] Long-time (former) USGS otter researcher James Estes pointed out in 2007 that USGS census data from that year showed "about a dozen sea otters per year making their way to Half Moon Bay, Pacifica and as far north as Point Reyes."[34] Even the National Park Service's website for Point Reyes National Seashore points out that "Every now and then, however, sea otters are seen in the waters of Drakes Bay—so keep your eyes open for them if you are visiting Chimney Rock. Beware, though, of misidentifying river otters as sea otters—both can be seen in the waters of Drakes Bay."[35]

Half Moon Bay and areas farther north are not included on recent USGS maps because USGS has apparently not surveyed Half Moon Bay or farther north since 2018. Additionally, USGS methodology for mapping the northernmost range extent requires "at least 5 otters [be] counted for at least 2 consecutive spring surveys during the last 3 years." Hatfield et al. 2019. Therefore, the locations of single otters or small groups that are infrequently observed (or missed during sequential surveys) would be insufficient to qualify as range expansion by the USGS. Regrettably, Petitioners find this to be circular reasoning, effectively "range-limitation by

---

[32] Lyon SN, Tomoleoni JA, Yee JL, Fujii JA, Thometz NM (2024) Foraging ecology of southern sea otters at the northern range extent informs regional population dynamics. Endang Species Res 54:383-394, https://doi.org/10.3354/esr01348.

[33] https://www.seaottersavvy.org/sea-otter-natural-history

[34] https://www.sfexaminer.com/news/sea-otters-numbers-climbing-on-county-coast/article_318619bd-cd99-595e-9153-3be1ca41779e.html

[35] https://www.nps.gov/pore/learn/nature/otters.htm

sampling design," whereby Southern sea otters are not considered to exist in areas where they are not surveyed because the survey methodology does not look for them there.

In conclusion, Petitioners find the observations of Southern sea otters from Half Moon Bay and Point Reyes indicative of natural sea otter behavioral ecology typical of all mammals: males explore new habitat in small numbers, which eventually leads to colonization of new areas by dispersing females. Regardless of the definition used to describe the northern range's extent, it is only 25-miles as-the-otter-swims from Half Moon Bay to the Golden Gate Bridge and access to abundant sea grass habitat in the San Francisco Bay. Petitioners concur with the overall results of Tinker et al. (2021a,b) that it is only a matter of time and opportunity for Southern sea otters to fully recolonize the San Francisco Bay and areas north on their own.

A.4.2) Tinker et al. (2021b), *Habitat Features Predict Carrying Capacity of a Recovering Marine Carnivore.*

The peer reviewed and published study by Tinker et al. (2021b) estimated potential carrying capacities for Southern sea otters along the California coast, San Francisco Bay, and Channel Islands. In other words, they measured the optimum number of otters that the habitat could potentially support given environmental factors in each area. These analyses were data-driven and utilized mapped data from standardized range-wide annual spring counts from mainland coast censuses conducted during 1983–2018 and San Nicolas Island from 1995–2018. They also included mortality data (including that attributed to shark bites) and habitat data (high resolution bathymetry, shoreline, rocky versus soft sediment substrates, ruggedness, otter distance to shore values, a GIS-based kelp canopy layer, and indirect measures of prey productivity using net primary production).

Tinker et al. (2021b) used 95% confidence intervals for bracketing estimates, thus that study produced predictions with higher confidence than Tinker et al. (2021a). The mean estimated carrying capacity for the central coast (current range) was 4,480 with a 95% confidence interval of 3,677–5,393. As the Southern sea otter's range expands, as predicted by Tinker et al. (2021b), an additional 4,035 (716 to 11,328) sea otters at carrying capacity were predicted for the San Francisco Bay, and 2,131 in the Channel Islands (914 to 4,470). Finally, an additional 3,513 (1,297 to 7,767) were predicted along the North Coast and an additional 3,067 (1,102 to 7,123) along the South Coast. When combined, estimated potential carrying capacity along the entire California Coast, San Francisco Bay, and Channel Islands was, in the author's own words, "that California could eventually support 17,226 otters" with a 95% confidence interval, or 9,739 to 30,087 otters including pups. While natural populations may take decades to ultimately reach carrying capacity, Tinker et al. (2021b) highlights a consistent upward trend in Southern sea otter population growth that is expected to continue moving forward.

A.4.3) Optimal Sustainable Population Abundance should not be added as a new delisting criterion.

The scientific and legal differences between delisting criteria established in Endangered Species Act (ESA) recovery plans and the criteria developed for Optimal Sustainable Population Abundance (OSP) used as a management goal under the Marine Mammal Protection Act (MMPA) are important to understanding Tinker et al. (2021b). Petitioners raise this distinction because Tinker et al. (2021b) estimated OSP values for Southern sea otters, but these should not be confused with their delisting threshold. These two measures address different goals: delisting thresholds measure a minimum number required for delisting and recovery whereas OSP values measure a maximum sustainable number under ideal conditions over an expanded range.

The Endangered Species Act ultimately hopes to improve the status of listed species until Endangered Species Act protections are no longer necessary for their survival and the species is delisted based upon "(ii) objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list."[36] In the case of the Southern sea otter, Petitioners have asked the Secretary to remove the Southern sea otter as a "threatened" species because new data and information provided in the 2021 petition and updated here prove it has exceeded its 2003 Recovery Plan objective delisting threshold. The subspecies is no longer "likely to become an endangered species within the foreseeable future."

In contrast, the Marine Mammal Protection Act (MMPA) defines OSP as an abundance value that falls between Maximum Net Productivity Level (MNPL) and carrying capacity (K). More specifically, NOAA defined these terms as:

> An **optimum sustainable population** is defined by the MMPA section 3(9), with respect to any population stock, as the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the **carrying capacity** [*K*] of the habitat and the health of the ecosystem of which they form a constituent element. (16 U.S.C. 1362(3)(9))
>
> Optimum sustainable population is further defined by Federal regulations (50 CFR 216.3) as a population size which falls within a range from the population level of a given species or stock which is the largest supportable within the ecosystem, to the population level that results in maximum net productivity. **Maximum net productivity** [MNPL] is the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth minus losses due to natural mortality.[37]

Therefore, a quantitative population threshold used as delisting criterion (under the ESA) is based on the minimum number needed to ensure that the species will not become an endangered species in the foreseeable future, while an optimum sustainable population size (under the MMPA) is a management goal based on maximum sustainable productivity. Therefore, these two values serve very different purposes and should not be confused or conflated. The 2003 Recovery Plan explicitly acknowledged this difference: "We recognize that both the current population and the minimum population size necessary for delisting under the Endangered Species Act are well below the optimal sustainable population level for this species and that the Southern sea otter will likely continue to be considered a depleted population under the Marine Mammal Protection Act."

---

[36] 16 U.S.C. § 1533(f)(1)(B)(ii).

[37] https://www.fisheries.noaa.gov/laws-and-policies/glossary-marine-mammal-protection-act#:~:text=Maximum%20net%20productivity%20is%20the,losses%20due%20to%20natural%20mortality

A.4.4) Reevaluation of delisting criteria, opined by Gagne et al. (2018), is not warranted.

A.4.4.1) A brief background on effective population size.

Effective population size (N_e) is an abstraction used in population genetics and conservation biology to estimate the approximate size of a theoretical, idealized population that would undergo genetic drift and inbreeding at the same rate as the real-world population under study. The concept and early derivation were introduced by population geneticist Sewall Wright in the 1930s. Such an idealized population requires five simplifying assumptions that are unrealistic (i.e., not found in Nature) but necessary for modeling effective population size in a computationally efficient manner. Briefly, those assumptions are that the population: is panmictic (completely random mating), has no population structure (all organisms in a population have equal chances of encountering each other), is unaffected by natural selection, has generations which do not overlap, and has an unchanging size over time.

In such an idealized theoretical population the effective population size would equal the census population size, but in Nature estimated effective population size is frequently lower than its census size. Multiple methods exist to estimate effective population size and, as shown in Gagne et al. (2018), different methods can produce very different results, even for the same population. Peer-reviewed literature also reveal that no method has proven superior to any other for estimating effective population size (Wang et al. 2016) and effective population size has proven to be an unreliable predictor of extinction risk (see Boyce 1993; Flather et al. 2011a,b for detailed analyses). Therefore, no method used to estimate the Southern sea otter's effective population size can claim to be more accurate or biologically meaningful than any other for predicting extinction risk or long-term population viability.

No universal measure can estimate extinction risk. In practical terms, estimating effective population size has only proven potentially useful in two cases. First, when a population actually exhibits a decline due to deleterious effects of inbreeding, it can be useful to understand just how inbred that population is compared to other populations of the same species to develop an effective management strategy (i.e., outbreeding with more genetically diverse populations). The second case is when a population is at an extremely low number (i.e., Mexican wolves down to 7 individuals, California condors down to 22 individuals) and it is important to design a structured breeding program to minimize inbreeding and conserve as much remaining genetic variation as possible in the long term. In that case, designing a breeding program to maximize the effective population size using different management strategies can be helpful. For the Southern sea otter, neither case applies.

A.4.4.2) ESA listing and delisting decisions must be made based solely upon data.

In reviewing such conservation-oriented papers and weighing the significance of statements made in the paper to a delisting decision, it is important to separate the data and results from the authors' opinions in the discussion and implications section of their papers. This is because ESA listing and delisting decisions must be based solely on data, not speculation, opinions, or interpretations of data expressed by the authors in the discussion sections of scientific papers. Petitioners report below how Gagne et al. (2018) (hereafter Gagne et al.) made multiple influential statements that were unsupported by data, inconsistent with their results, erroneous, or nothing more than the authors' opinions.

A.4.4.3) Issues of significance found in Gagne et al. (2018).

Gagne et al. reported results of population genetic analyses obtained from a spatial and temporal survey of genetic diversity and population structure across the Southern sea otters' range. Additionally, several alternative methods were used to estimate effective population size. Those methods included demographic methods (using life table data) and genetic methods (linkage disequilibrium and sibship frequency estimated from microsatellite data).

A key point to keep in mind in reviewing Gagne et al., and similar microsatellite survey papers, is that microsatellites are genetic markers that are selectively neutral, meaning that they do not code for proteins or regulate the expression of other genes. Therefore, they do not quantify genetic variation directly involved in survivorship, reproduction, or population persistence. Microsatellites are short tandem repeats of non-coding DNA (i.e., …ACACACACAC…). In other words, they are not directly subject to the forces of natural selection (unless closely linked to genes under selection nearby on the same chromosome, which has not been demonstrated by mapping for any of the microsatellite loci in the Gagne et al. study).

Additionally, compared to the overall size of the haploid (one of two copies per cell) nuclear genome which is billions of base pairs in length (i.e., more than two billion base pairs of DNA in humans for example, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5748697/), the 38 microsatellites surveyed by Gagne et al. comprise 15,992 base pairs or less of repeats (based on a sum of microsatellite allele sizes using the raw data from Gagne et al. (2018 supplement material). Thus, while useful for estimating basic population genetic parameters, the extent of DNA sampled by Gagne et al. is negligible relative to either the length of the genome or the number of protein-coding and regulatory genes in the genome that natural selection acts upon. In other words, Gagne et al. did not survey the genetic diversity that contributes to both individual survival and the species' evolutionary potential using microsatellite markers.

The results reported by Gagne et al. on microsatellite genetic diversity, population structure, and estimates of effective population size using different methods, are straightforward. However, the opinions expressed by Gagne et al. interpreting their results' significance to the Southern sea otter's delisting are erroneous and potentially biased towards maintaining an ongoing listing of the Southern sea otter. The results also conflict for the reasons detailed below.

As an initial matter, regarding their microsatellite genetic diversity results, Gagne et al. stated in the discussion section of their paper that:

> … given the multiple threats impacting the southern sea otter population (including disease and shark bites), and because range expansion has stalled over the past two decades due to increased mortality at the northern and southern range peripheries (Lafferty & Tinker, 2014; Tinker & Hatfield, 2016; Tinker et al., 2016), it seems unlikely that demographic factors will enhance genetic diversity in the immediate future.

This opinion is incorrect in two ways. First, data analyzed by Tinker et al. (2021a,b) show that range expansion has *not* stalled over the past two decades but has continued: “the mean predicted rate of range expansion along the mainland coastline (excluding estuaries and islands) was 3.7 kilometers per year (km/yr) to the south and 2.9 km/yr to the north.” Second, Gagne’s statement that, “it seems unlikely that demographic factors will enhance genetic diversity in the immediate future,” is speculative. No analysis was presented to support this statement and no value was assigned to a vague time frame of “the immediate future.”

Next, Gagne et al. opined that:

> Our findings also reveal that an increase in population size did not result in a corresponding increase in genetic diversity, suggesting that population size is not always a suitable substitution for direct measurements of genetic diversity, particularly for closed populations that have experienced severe population bottlenecks (Frankham, 2010).

Gagne et al. provided no analysis to show that an increase in microsatellite diversity would be expected over the short time frame (one to two generations) or even detectable with the limited number of microsatellites and individuals surveyed after one to two generations. However, even basic calculation—multiplying an average microsatellite mutation rate of 10^{-4} events per locus per generation[38]—the number of microsatellites sampled (N=38), and the number of individuals sampled between 2000 and 2005 (n=423) reveals that only two or fewer mutations could potentially be present in a sample of that size. A lower mutation rate or mutations arising due to convergence in repeat number (known as homoplasy) would result in no potentially detectable mutations. Thus, the probability of detecting new microsatellite genetic variants by Gagne et al. was vanishingly small because not enough generations had elapsed, and not enough microsatellites and individuals had been sampled.

Next, Gagne et al. acknowledged that not enough time may have elapsed to detect new microsatellite variation, which contradicts their previous assertion that “an increase in population size did not result in a corresponding increase in genetic diversity.”:

> The study period, however, only encompassed the time span of one or two generations (generation time of 7.9 years, estimated from life history table) and, due to a lack of gene flow with northern sea otters, any increases in diversity would have to be driven by mutations, thus our sampling period may be too short to detect increases in genetic diversity.

That acknowledgment also contradicts the following assertion, made in the opening sentence of the *Conservation implications* section of their discussion:

> Long-term analyses suggest that genetic diversity in southern sea otters is not increasing despite the continued, though sluggish, increase in population size.

---

[38] Microsatellite mutation rates reported by Li et al. (2002) were typically between 10^{-2} and 10^{-6} events per locus per generation.

Gagne et al., lacking data that Southern sea otters are highly inbred or have genetically-based morbidities or mortalities that can be demonstrated to reverse the trend of population increase, resorted to an *ipse dixit* argument.[39] Gagne et al. attempted to dismiss the current uplisting and delisting criteria in the Recovery Plan and propose new, yet-to-be-determined, delisting criteria. The flaws in their argument are listed as follows:

1) The delisting criteria are based on the total number of Southern sea otters, 3,090, not an effective population size (N_e) of 500, as incorrectly reported by Gagne et al. As Petitioners noted previously, an N_e of 500 using the demographic method is the threshold between *endangered* and *threatened* status in the recovery plan, not the threshold for delisting.

2) Their argument ignores their own finding that Southern sea otters have exceeded an N_e size of 500 (1,850 animals). Their demographic N_e estimate was 544 to 1,145.

3) Gagne et al. fail to acknowledge (or were unaware of) the $N_e \geq 500$ "rule of thumb," the basis of the Recovery Plan's endangered threshold for population number, which lacks a sound scientific basis. (Please see below for detailed analysis of the $N_e \geq 500$ "rule of thumb.")

4) Their argument predates more recent census data that clearly show the number of Southern sea otters exceeds the Recovery Plan's numeric delisting threshold of 3,090.

Gagne et al. then contend that, because different methods for estimating effective population size can yield different estimates, and that their genetic estimates of N_e were difficult to explain, the demographic method for estimating N_e as described in the Recovery Plan is inappropriate for delisting. However, they do so without explaining why:

> discrepancies in genetic and demographic estimates of N_e are problematic in terms of providing a simple N_e-based metric to support decisions about management and conservation of southern sea otters. Our results suggest that the genetic estimates of N_e at the range-wide scale are too low because of the problem of applying genetic estimates over a large geographic range in which there may be cryptic genetic structure due to isolation by distance. If we instead use the demographic estimate of N_e, and account for the potential bias introduced by differences in lifetime reproductive success (a 10%–50% reduction), we estimate that the current N_e of the southern sea otter population is between 544 and 1,145.

---

[39] *Ipse dixit* is a Latin term that translates to "he himself said it," a bare assertion resting on the authority of the individual(s) making it, rather than supporting evidence or sound reasoning (see https://www.law.cornell.edu/wex/ipse_dixit and Cicero 45 BCE, *De Natura Deorum.* As translated in De natura deorum; Academica; with an English translation by H. Rackham 1933, W. Heinemann, London. Full text available: https://archive.org/details/denaturadeorumac00ciceuoft).

Finally, Gagne et al. (2018) make two additional unfounded assertions to support their conclusion “that the current delisting criterion is not appropriate for southern sea otters.” The first, that “N_e is not increasing with the growth of the population,” is unfounded because, as described above, their microsatellite data and methods lacked sufficient resolution to detect such a change over only one to two generations. Also, they omit that, by definition, the simple demographic N_e method produces estimates that will be correlated with population size. The N_e method’s estimates, therefore, will increase as the population increases in size. The second assertion, “because we are unable to provide a single precise estimate of the number of otters corresponding to an N_e of 500 as required by the recovery plan,” is unfounded because they ignored that different methods for estimating effective population size, demographic or genetic, can yield different estimates (Husemann et al. 2016). And, as noted above, the 2003 Recovery Plan’s delisting criteria rely on the population number exceeding 3,090 for three years, and not an N_e of 500 or greater.

Gagne et al.’s opinion that population viability analyses could better inform delisting decisions, instead of the current delisting criteria, misses the mark. The best available scientific data on the Southern sea otter population number (from census data) and projected trends into the foreseeable future (Tinker et al. 2021a,b) reveal that they have surpassed their delisting threshold and will continue to increase in number and occupied range.

To date, no simple measure of genetic diversity can reliably predict a species’ probability of persistence (Flather et al. 2011a,b). Additionally, non-genetic behaviors, as described in a new paper in the journal *Nature* (Lenart et al. 2022), reported simulation results that learning (i.e., to avoid predators) “can mitigate loss of genetic diversity caused by drift, by creating a pool of harder-to-die individuals that protect alleles they carry from extinction.” Thus, in species with a high capacity for learning, effective population sizes are highly likely to be revised upwards. Being intelligent and capable of learned behaviors, sea otters fit this category.

A.4.4.4) Conclusion: demographic and genetic considerations.

It is important to note that the Southern sea otter was listed as a *threatened* species in 1977 (US Fish and Wildlife Service 1977), not an *endangered* species. The Service’s rationale in the Federal Register was:

> [W]hile present population estimates were debatable, it was thought that the Sea Otter was increasing in range and numbers and would continue to do so, if permitted. The Sea Otter thus was not considered to be endangered, but several threats were held to be problems, the most serious being the potential impact of oil spills. It was suggested that a large number of animals could be jeopardized by a major oil spill. The Commission therefore recommended that the Southern Sea Otter be listed as threatened.[40]

The criteria for uplisting and delisting from threatened status, subsequently established in the recovery plan, were to ensure the survival of a sufficient number of Southern sea otters after a

---

[40] 42 Fed. Reg. 2,965, 2,966 (Jan. 14, 1977).

potentially catastrophic oil spill (>250,000 barrels) from a tanker accident, or six or more smaller (1,000 barrel) spills. At the time, primitive single-hulled oil tankers with technology similar to the Exxon Valdez were regularly anchoring offshore in the Southern sea otters' range to off-load oil at electrical power generating stations and load oil from coastal oil fields, with supertanker ports being planned. However, as described in our Petition, economics, pre-disaster planning, and technological innovations have made the threat of large catastrophic oil spills *de minimis*.

It must be noted in the evaluation of demographic data, discussed in the Petition and this update, that the delisting threshold for Southern sea otters in the 2003 Recovery Plan did not rely on maintaining an effective population size of 500 as asserted by Gagne et al. (2018). Instead, the recovery team articulated quantitative thresholds for *delisting* the Southern sea otter based on the population reaching 3,090 averaged over three years. That number was selected because it allowed the Service to detect declining trends in abundance while the species was in threatened status before the population reached the threshold for endangered status:

> Assuming a sample variation in annual counts of 10 percent and a population decline of 5 percent per year, it would take 10 years to detect reliably (i.e., type I error equals 0.10) a decline prior to reaching a population size of 1,850. A 5 percent rate of decline over a 10-year period resulting in a population of 1,850 animals would require an initial population size of 3,090. In other words, a population of 3,090 animals or larger (i.e. 1,850 + 1,240) is sufficiently large that we can expect to be able to detect with adequate statistical assurance a significant (i.e., greater than 5 percent per year) declining trend in abundance prior to the population reaching the threshold for endangered [i.e. less than 1,850].
>
> In summary, given that the goal of management prior to delisting the species under the Endangered Species Act is to have a minimum of 1,850 otters in California following a major oil spill event and also to be able to detect reliably a population decline before reaching this number, the necessary abundance of sea otters in California, averaged over a 3-year period, is equal to 1,850 (the minimum viable population size), plus 1,240 (a size sufficient to incorporate an expected level of mortality from an oil spill the size of the Exxon Valdez and to allow for the reliable detection of a population decline), or 3,090 animals.
>
> Accordingly, the preliminary or milestone criteria for threatened and delisted status for the southern sea otter under the Endangered Species Act are as follows:
>
> ENDANGERED: The southern sea otter population should be considered for reclassification as endangered under the Endangered Species Act if the population declines to a level fewer than or equal to an effective population size of 500 animals (Mace and Lande 1991). Until better information is available, we recommend using a multiplier of 3.7 to convert effective population size to actual population size (Ralls et al. 1983), or 1,850 animals. Therefore, the southern sea otter population should be considered endangered if, based on standard survey counts (i.e., spring surveys), the average population level over a 3-year period is fewer than or equal to 1,850 animals.

> THREATENED: The southern sea otter population should be considered threatened under the Endangered Species Act if the average population level over a 3-year period is greater than 1,850 animals, but fewer than 3,090 animals.
>
> DELISTED: The southern sea otter population should be considered for delisting under the Endangered Species Act when the average population level over a 3-year period exceeds 3,090 animals.
>
> However, it should be recognized that the number of otters that make up this population will never be known with certainty. Nor will the rate of change be known with certainty. Therefore, it is necessary for the classification criteria to incorporate uncertainty and the extent to which changes in abundance can be reliably detected. Based on public comments and recommendations from the Recovery Team, we believe that an adequate minimum threshold difference between the criteria for endangered and threatened status is 1,240 animals. This number is roughly the decrease in animals over a 10-year period that could be detected reliably with the current level of precision in counting sea otter abundance off the coast of California if the decline were at a rate of 5 percent annually. This number also represents a plausible number of otters that might be killed in a short period of time if there were an oil spill of a magnitude comparable to that of the Exxon Valdez.

These are the thresholds established in the Recovery Plan. Delisting is not contingent upon an Ne>500, as suggested by Gagne et al. (2018), regardless of methods used to estimate it. While the original Ne≥500 criteria may no longer be valid, it served its purpose by protecting the Southern sea otter population and preventing it from becoming an endangered species. As shown by 2019–2021 survey data, and analyses by Tinker et al. (2021a,b), the Southern sea otter population has increased over time and will continue to increase into the foreseeable future.

A.4.4.5) Why an effective population size $N_e \geq 500$ "rule of thumb" lacks a sound scientific basis.

Although it has been cited in conservation literature, including Gagne et al.'s (2018) proposed application of it to Southern sea otters, no universal correlation between estimated effective population size and extinction risk exists. This includes the Ne≥500 "rule of thumb"—that the effective population size must be equal to or greater than 500 to maintain evolutionary potential of a population (Franklin 1980). Although often cited in species management plans and used as a basis of Minimum Viable Population analyses (MVP), the Ne≥500 rule of thumb has a scant and tenuous scientific basis, the factual and theoretical details of which appear to be unknown to many of those citing it, so the details are presented below for sake of a full understanding of why it lacks a sound scientific basis.

Regardless of effective population size estimated via any method, the Southern sea otter population has expanded in both number and range and is predicted to continue to do so moving forward. No deleterious genetic issues have been identified that have compromised population growth. And, if there is future translocation of unrelated otters from the northern population into the Southern sea otter range, this would provide additional genetic diversity.

The suggestion that a minimum effective population size of 500 individuals is necessary to maintain a population's evolutionary potential (i.e., its ability to adapt to a changing environment) and population viability dates back to a simplistic, quantitative genetic model developed by Franklin in 1980. Franklin believed that most important adaptive changes are the result of selection on continuously varying characters. Therefore, Franklin reasoned that a quantitative genetic approach, rather than a population genetic approach, was needed for the long-term conservation of genetic variation. Franklin's model (1980) described the conditions under which an equilibrium could potentially be maintained in a finite (i.e., unchanging) population between the loss of additive genetic variance through genetic drift and the amount gained via mutation over many generations. The model assumed no natural selection occurring in the theoretical population.

From quantitative genetics, a population's phenotypic variance (the variance in measurable external, behavioral, or physiological characteristics) has been generally apportioned into three components: environmental variance, genotypic variance (the genetic basis), and the genotype-environment interactive variance (Franklin 1980). The proportion of genotypic variance can be further broken down into additive, dominance, and epistatic variance components. Of these, the additive genetic variance is the most important to the genetically determined characteristics of a population that will potentially respond to natural selection. The additive genetic variance, therefore, is of long-term evolutionary importance.

In very small populations, loss of genetic variability through genetic drift will generally be greater than that gained through mutation. Franklin (1980) assumed that, if all a population's genotypic variance is additive (no dominance or epistatic variance), then the rate of loss of additive genetic variance will be roughly equal to the rate of loss of heterozygosity or $1/2N_e$ per generation. To determine a potential rate of gain for additive genetic variance in quantitative characters from mutation alone, Franklin (1980) relied upon "rough" estimates from previous research by Lande (1976). That literature review summarized results from several previous reviews of earlier studies (i.e., 1940s to 1960s) on highly inbred lines of mice, maize, and *Drosophila*. The original studies measured skeletal characteristics of highly inbred lines of mice (i.e., via repeated full-sib matings over tens to hundreds of generations), physical characters of maize that was also highly inbred (i.e., that had been self-fertilized for ten generations), and finally, abdominal and sterno-pleural *bristle hair number* of *Drosophiola melanogaster* from inbred lines that had been living in glass vials for several hundred generations (Figure 2, below).

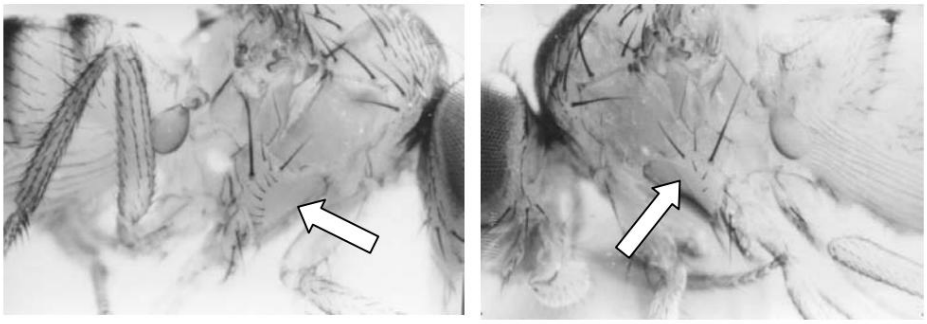


Figure 2. Sterno-pleural "heart-shaped" section of two *Drosophila* marked with white arrows. Sternopleural bristle numbers are: left, 11; right, 6 (Woodruff and Thompson, 2005).

Figure 2. Location of sterno-pleural bristle hairs of *Drosophila melanogaster.* The heritability of sterno-pleural and abdominal bristle hair number influenced Lande's (1976) choice of a "rough estimate" of the rate of gain for additive genetic variance in quantitative characters from mutation alone. That "rough estimate," as disputable as it is, forms the foundational basis of the Ne>500 rule of thumb that has been unquestioningly applied to distantly related species, including Southern sea otters.

From the heritability estimates averaged by Lande (1976), the proportion of additive genetic variance from mutation was thought to be approximately 10^{-3} that of the environmental variance. From that review, Franklin (1980) reasoned that, if the loss and gain of additive genetic variance is to be equal in a population, or $1/2N_e = 10^{-3}$, then N_e must equal 500. Accordingly, for populations to gain additive genetic variance, then N_e must be larger than 500. That is the extent of empirical evidence and rationale used to support Franklin's (1980) conclusion and the Ne>500 rule of thumb. Somehow, Ne>500's questionable founding basis, including the unrealistic assumptions used in the development of Lande (1976) and Franklin's (1980) simplistic models, is ignored throughout its repeated use in the conservation literature.

Clearly, decades-old summaries drawn from studies of inbred lines of mice, fruit flies, and maize, coupled with simple models requiring assumptions not found in wild populations, are of questionable validity when managing Southern sea otters and other species. Yet, without questioning the evidentiary basis of the Ne>500 rule of thumb, some authors, including Gagne et al. (2018), have continued to embrace and rely upon it when evaluating extinction risk. Such reliance contradicts peer-reviewed literature that reveals effective population size to be an unreliable predictor of extinction risk (see Boyce 1993; Flather et al. 2011a,b).

The most recent scientific literature on adaptive genetic variation, Bonnet et al. (2022), reveals that additive genetic variance measured in wild populations of mammals and birds is far higher than had previously been estimated by conventional methods such as those used by Lande (1976).

B. Overutilization for commercial, recreational, scientific, or educational purposes.

The Service has previously determined that overutilization for commercial, recreational, scientific, or educational purposes "is not currently an issue, nor would it become an issue if sea otters were delisted[.]" 2015 Status Review. Petitioners are not aware of any newer demographic data that would undermine this conclusion.

C. Disease or predation.

The Service has previously noted that shark predation, food limitation, and disease are leading causes of sea otter mortality. 2023 Species Status Assessment. However, analyses of data via integrated population modeling, specifically USGS census data over the past decade and population projections by Tinker et al. (2021a,b), reveal that these factors do not threaten the sea otter with extinction moving forward but are, at most, natural checks on their continued expansion.

C.1) Disease.[41]

Southern sea otters, like virtually every other species of mammal, are host to a wide variety of infectious diseases and parasites. Influenza A virus, parvovirus, polyomavirus, adenovirus, naso-pharyngeal mite, acanthocephalan peritonitis, *Sarcocystis neurona*, *Streptococcus phocae*, *Toxoplasma gondii*, *Brucella, Helicobacter*, and tapeworms are among the pathogens and parasites documented in Southern sea otters over decades of intensive study. Similarly, biotoxins produced by *Pseudonitzschia* and *Microcystis* are found in the marine environment and can affect individual sea otters. Wounds, infection, and bacterial septicemia have also been documented to occur from shark bites as well as from male Southern sea otters biting females during mating and other aggressive interactions. However, none of these parasites, pathogens, toxins, or secondary infections have been shown by data to threaten the Southern sea otter's continued existence, even in combination with other diseases or environmental factors. Southern sea otters, like humans and other species of mammals, are infected by a wide variety of parasites and pathogens, many of which have coevolved with their mammalian hosts. And as with humans and other mammals, these parasites, pathogens, and biotoxins tend to affect individuals differently and have local effects that may vary over time.

Below, Petitioners highlight recent data, modeling results, and evolutionary insights on two pathogens, *Toxoplasma gondii* and *Sarcocystis neurona*, that have been reported as a leading or contributing causes to mortality of Southern sea otters. Petitioners give special consideration to *T. gondii* because of the attention it has received in the literature on the purported link between otter mortality and domestic cats in urban areas. New data have discredited this popular claim.

C1.1) *Toxoplasma gondii.*

Toxoplasma gondii (*T. gondii*) is an obligate intracellular parasite in the Phylum *Apicomplexa*, that includes other notable parasites such as *Plasmodium* (malaria) and *Cryptosporidium*. *T. gondii* is not unique to sea otters. It has worldwide distribution and infects virtually every species of mammal in the terrestrial and marine environment, most bird species, marine mollusks, and some fish. It infects approximately 30% of the human population worldwide, with infection rates varying between 10 to 90% in different regions (Dubey 2010; Torgerson and Mastroiacovo 2013; Ehmen and Lüder 2019). The Centers for Disease Control estimates that 40 million people in the USA are infected with the parasite.[42] Most mammals and humans show no signs of illness from acute or chronic infection unless their immune system is compromised,

---

[41] Updated data and information, from Petitioners' 2021 petition.

[42] https://www.cdc.gov/parasites/toxoplasmosis/index.html

they acquire the infection during pregnancy, or they are infected with virulent strains of *T. gondii*.[43]

As described recently by Jeffers et al. (2018), "[u]pon initial infection of an immunocompetent host with *Toxoplasma*, an often asymptomatic acute infection (tachyzoites) is followed by establishment of chronic infection, which is marked by the formation of intracellular tissue cysts (bradyzoites). These cysts can persist within the host tissues throughout the life of the host, maintained in the quiescent state by its immune system." These dormant tissue cysts facilitate *T. gondii's* persistence by remaining in the intermediate host until it may be preyed upon or scavenged by felids, thus continuing the parasite's life cycle. If an individual's immune system becomes suppressed, these dormant intracellular tissue cysts (called bradyzoites) can transition back into rapidly proliferating tachyzoites, causing morbidity or mortality.

Sexual reproduction of *T. gondii* begins with wild and domestic felids (i.e., bobcats, mountain lions, and domestic cats in North America) consuming infected intermediate hosts. Felids are "definitive hosts" essential to *T. gondii's* life cycle because the sexual reproduction phase of the parasite's life cycle is only known to occur in felids' guts. Di Genova et al. (2019) recently discovered why this occurs: "Cats lack an enzyme called delta-6-desaturase, which catalyzes the conversion of linoleic acid to arachidonic acid, accounting for the peculiarly high levels of linoleic acid in the cat intestine, but not in other mammals." High linoleic acid is required by *T. gondii* for sexual reproduction. Infected felids shed millions of oocysts in their feces, which are highly persistent in the environment. Oocysts can survive for a year or more in the terrestrial environment before being ingested by both "natural intermediate hosts" (i.e., species that felids prey upon) or "accidental intermediate hosts" (species not preyed upon by felids and therefore "dead-ends" for the parasite, such as humans, livestock, and sea otters). *T. gondii* oocycts are hardy enough to survive being washed into the sea where they may be ingested by marine mollusks and, subsequently, marine mammals and fish (Massie et al. 2010; Shapiro et al. 2014, 2019a; Carlson-Bremer et al. 2015; Krusor et al. 2015).

C.1.1.1) The Southern sea otters' continued existence is not threatened by domestic cats.

Several scientific papers and provocative articles in the press (i.e., Miller et al. 2008; New York Times 2003, 2019; Smithsonian 2019) have claimed that domestic house cats and outdoor cats in urban areas are killing sea otters by spreading *T. gondii* infections (Miller et al. 2008, 2013). The most recent articles appear to stem from a UC Davis press release about a paper by Shapiro et al. (2019b). In the discussion section of that paper, the authors speculate that a spillover of oocysts with a virulent wild type X genotype of *T. gondii* (or its similarly toxic variants) is occurring from wild felids (i.e., bobcats and mountain lions) to domestic cats. That spillover, in turn, will increase the frequency of type X in the much larger domestic cat population, thus leading to more virulent type X genotypes washing into the ocean from urban surface areas, increasing sea otter mortality. This speculation implies that domestic cats disproportionately contribute to sea otter mortalities near developed areas, thus the news headlines such as "*Parasite Spread by House Cats Is Killing California's Sea Otter*" (Smithsonian 2019).

---

[43] http://www.cfsph.iastate.edu/Factsheets/pdfs/toxoplasmosis.pdf

While the wild type X genotypes were found in a handful (n=6) of feral and domestic cats during the limited cross-species sampling by vanWormer et al. (2014), no evidence was presented by Shapiro et al. (2019b), or others, that domestic cats were shedding large numbers of type X oocysts into the environment or that these type X genotypes were sweeping into the domestic cat population. Shapiro et al. (2019b) also downplayed published experimental data and pathology results that indicated a limited ability of domestic cats to shed type X genotypes of *T. gondii* (i.e., wild felid strains). This is an important misstep in their research reporting because coevolution between domestic cats and *T. gondii* strains in the domestic cat cycle (especially those possessing the monomorphic Chr1a chromosome) limits the transmission of wild felid strains of *T. gondii* to domestic cats, as noted by Galal et al. (2019):

> Experimental infections of domestic cats with domestic strains of *T. gondii* (4 strains for 8 cats) and with wild strains (3 strains for 6 cats) have shown that these two categories of strains do not have the same capacity to be transmitted by the domestic cat (Khan et al., 2014). The 4 domestic strains caused oocyst excretion in 6 of the 8 exposed cats (2 strains caused oocyst excretion in only one of the 2 exposed cats) while the 3 wild strains were associated with oocyst excretion in only one of the 6 cats exposed. This monomorphic ChrIa [chromosome] could confer a selective advantage to domestic strains for being disseminated by the domestic cat through oocyst shedding. This adaption could therefore facilitate their spread in the domestic environment and strengthen this dichotomy between a wild cycle and a domestic cycle.

These same issues were raised by a peer review of the original manuscript submitted by Shapiro et al. (2019b). However, the final manuscript alluded to feral domestic cats, because of their presumed large number, as the primary vector of type X and threat to sea otters. An excerpt of that peer review, provided below, may be found online with the peer reviews and responses.[44]

> 8. 371: The authors argue that “The molecular identity of atypical *T. gondii* strains in sea otters that died due to toxoplasmosis and nearby feral domestic cats demonstrate how land-to-sea flow of lethal pathogens from domestic animals can impact wildlife health in coastal ecosystems.” This point is crucial in a framework of species conservation as it attributes the death in sea otters to domestic cats. However, there is no strong evidence that domestic cats are shedding *T. gondii* of type X (which is the virulent type). The fact that domestic cats are found infected by a given strain does not mean that they can shed this strain in the form of oocysts as previously shown in an experimental study (Khan et al., 2014 Plos NTD). The results of this previous study also showed that domestic cats may not efficiently shed wild types of *T. gondii*, although this merits to be verified for a larger diversity of wild types including type X. This is a knowledge gap that deserves to be pointed out in the context of this study as it is a crucial point in terms of species conservation and future policies. **Instead, wild felids, which are also prevailing in the study area, appear to be the most likely definitive hosts for this *T. gondii* type.** [Petitioners’ emphasis.] Indeed, type X is mainly associated to the wild environment in

---

[44] https://royalsocietypublishing.org/action/downloadSupplement?doi=10.1098/rspb.2019.1334&file=rspb20191334_review_history.pdf

> North America. It was mainly isolated in wild felids, wild intermediate hosts and species that have contact with the wild environment (reviewed by Jiang et al., 2018 IJP).

Identical issues plague a recent paper by Zhu et al. (2023) (from Shapiro's research group). In that paper, the authors reported detecting DNA of *T. gondii* in feral cat feces using PCR amplification, including detecting type X *T. gondii* DNA. Interestingly, no actual type X *T. gondii* oocysts could be found. In other words, if type X oocycts were found, it would indicate that feral cats can shed and spread type X *T. gondii* oocysts in storm runoff to sea otters. However, the detection type X *T. gondii* DNA alone (without infective oocycts) most likely means that DNA from non-infective tissue cysts from the digestion of rodent prey was detected in cat feces instead. Despite these clearly important methodological problems, Zhu et al. (2023) went on to make the bold, yet unsupported, claim that "[l]arge populations of feral cats and T. gondii contamination near marine habitats can pose a risk for threatened and endangered marine mammals [i.e. southern sea otters]."

And finally, both Shapiro et al. (2019b) and Zhu et al. (2023) did not mention the critical review by Lafferty (2015) or cite readily available, peer-reviewed medical-evolutionary genetic literature, such as Shwab et al. (2018) or Galal et al. (2019). Those publications obviously conflict with the speculation that domestic cats are spreading type X *T. gondii* to sea otters.

Inaccurate claims that domestic cats are killing sea otters by spreading *T. gondii* oocysts have been around since at least 2003 (see Lafferty 2015 for an extensive, critical review). This claim has persisted in sea otter scientific literature and in the press despite abundant contrary evidence. That contrary evidence includes data on the toxicity and clustering of virulent type X genotypes in undeveloped areas that are maintained in wild felid cycles by bobcats and mountain lions (see Figure 3 of vonWormer et al. 2014). New data and modeling results (Jiang et al. 2018; Shwab et al. 2018; Galal et al. 2019) have also demonstrated how and why natural selection maintains *T. gondii* strains of low virulence in domestic cat infection cycles but creates strains of high virulence in wild felid cycles. This later body of recent, highly relevant medical-evolutionary research literature, and its significance to sea otter conservation, appears to have escaped notice by the Service and leading otter researchers.

The assumption that domestic cats kill sea otters is part of a popular paradigm that sea otters serve as "sentinels" of ecological health of the ocean and that sea otter morbidity and mortality will map onto human development and activity (i.e., Jessup et al. 2004; Conrad et al. 2005; Miller et al. 2008). This has spawned notable spin-offs, such as the "kitty litter hypothesis" and "pet cat hypothesis," based on the assumption that *T. gondii* oocysts from domestic cats are being flushed down toilets and washed into the sea, subsequently infecting and killing sea otters. This led Governor Schwarzenegger in 2006 to sign into law AB 2485 requiring kitty litter packaging to have labeling admonishing cat owners to dispose of cat feces in the trash rather than the toilet, thereby sparing sea otters toxic *T. gondii* infections.[45] However, as noted by Lafferty (2015), this paradigm was already contrary to available data in 2014. More recent data and modeling results conflict with this paradigm (Shwab et al. 2018 and supplemental materials; Galal et al 2019), yet it persists as speculation and opinions expressed in the discussion sections

---

[45] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200520060AB2485. Outside cats, feral cats, bobcats, and mountain lions were obviously not covered by this legislation because they do not use litter boxes.

of various scientific papers (i.e., Shapiro et al. 2019b). Regrettably, such surmise can sometimes be confused with experimental data and rigorously tested hypotheses by uninformed decision-makers and an uncritical press.

Lafferty (2017) concisely summed up the situation as follows:

> Because stranded sea otters with toxoplasmosis were most common near river mouths (Miller et al. 2002), veterinarians suggested that sea otters were sentinels of a dirty ocean (Jessup et al. 2004), blaming domestic and feral cats and urging pet owners to stop flushing pet waste into the sewer. To support this contention, researchers devised a study to compare sea otter infection and mortality rates at two locations: the populated Monterey Bay and the rural Big Sur coast (Tinker 2013). Counter to expectations, *T. gondii* was not a substantial mortality source in the study (Miller et al. 2013), and the rural Big Sur otters were many times more likely to become infected with *T. gondii* (Burgess et al. 2013), perhaps due to Big Sur having more bobcats and mountain lions that, like domestic cats, carry the parasite (Lafferty 2015). Ironically, both parasites that impact sea otters are more prevalent where other wildlife is common (Lafferty 2015, Smith 2007), casting doubt on whether these sea otter diseases indicate a degraded environment.

C1.1.2) New data, modeling results, and insights into the evolution and maintenance of *T. gondii* strains explain why domestic cats do not threaten sea otters.

Both Shwab et al. (2018) and Galal et al. (2019) report that natural selection operates on *T. gondii* virulence (and type X host specificity in particular) very differently in domestic cat versus wild felid populations. Briefly, there is strong selection for lower virulence in domestic cat populations, where there are few intermediate hosts, and intermediate to high virulence selection for wild felids, where there are numerous intermediate host species. This hypothesis is well-supported by multiple lines of evidence and is not in conflict with any data Petitioners are aware of.

The mechanisms behind the opposite selective regimes in wild versus domestic cats are straightforward. Natural selection favors less virulent genotypes in domestic cat populations because there is low diversity of intermediate hosts preyed upon by domestic cats (primarily the house mouse, *Mus musculus*) and only one species of definitive host, the domestic cat. Prolonged, non-lethal *T. gondii* infections to mice allow for subsequent transmission to cats that prey on mice and the deposit of oocysts that subsequently infect the same mouse species, thus favoring low virulence over more virulent strains that prematurely kill these intermediate hosts (i.e., type X strains). However, in the wild (sylvatic) the situation is the opposite: a high diversity of intermediate hosts and definitive hosts favors higher levels of *T. gondii* virulence.

Additionally, experimental evidence has also shown a coevolutionary response of cats to *T. gondii* strains of low to intermediate virulence. When domestic cats are infected with type X strains of *T. gondii*, they do not shed oocysts as efficiently as wild felids (Khan et al. 2014; Galal et al. 2019).

In other words, while spillover of virulent (type X) *T. gondii* strains can occur from wild felids to domestic cats (as shown in Shaprio 2019), natural selection will winnow away the more virulent wild (type X) in the domestic cat population such that they cannot be maintained. Recent modeling (Shwab et al. 2018; Galal et al. 2019) supports this conclusion.

Dormant tissue cysts facilitate *T. gondii's* persistence, especially in the domestic cat/mouse cycle. This occurs because mice infected with *T. gondii* strains of low to intermediate virulence tend to live longer than those parasitized by virulent strains. This in turn increases the chances of transmission to cats, perpetuating the *T. gondii* life cycle (Shwab et al. 2018; Galal et al. 2019). In contrast, during the sylvatic cycle (in the wild), there is greater diversity of natural intermediate host species, felid species, and transmission through both predation and scavenging. These factors favor the evolution and maintenance of more virulent strains of *T. gondii* (Shwab et al. 2018 and supplemental material).

Fortunately, North America has only four primary clonal strains of *T. gondii* circulating: types I, II, III, and 12 (the type 12 lineage includes type A and X strains from sea otters). The type 12 lineage is the dominant isolate found in wildlife in North America (46.7% of isolates), followed by types II and III that are typically found in domestic animals and humans (Dubey et al. 2011). In contrast, South America has both the highest diversity of *T. gondii* found on any continent and many highly virulent strains of *T. gondii*. New phylogenetic analyses by Bertranpetit et al. (2017) reveal that *T. gondii* strains share a most recent common ancestor in South America. As summarized by Bertranpetit et al. (2017):

> We show that extant strains of the pathogen likely evolved from a South American ancestor, around 1.5 million years ago, and reconstruct the subsequent spread of the pathogen worldwide [first into North America, then through the Bering Strait to colonize Asia, Europe and Africa]. This emergence is much more recent than the appearance of ancestral *T. gondii*, believed to have taken place about 11 million years ago, and follows the arrival of felids in this part of the world. We posit that an ancestral lineage of *T. gondii* likely arrived in South America with felids and that the evolution of oral infectivity through carnivorism and the radiation of felids in this region enabled a new strain to outcompete the ancestral lineage and undergo a pandemic radiation.

A subsequent spread of a few clonal strains worldwide in domestic cats and evolution of a separate domestic cat *T. gondii* cycle is consistent with the development and spread of agriculture approximately 11,000 years ago. Also, when international ship-borne trade started in the 16th century, "ships populated by rats, mice, and cats provided *T. gondii* with unprecedented migration opportunities." (Lehman et al. 2006; Bertranpetit et al. 2017; Shwab et al. 2018; Galal et al. 2019).

C.1.1.3) Significance of new research on the evolution of *T. gondii.*

Regrettably, the new data and understanding of *T. gondii* ecology, host specificity, and evolution of virulence have not caught the attention of the sea otter research community. For example, a recent paper by Burgess et al. (2018) reports that they have identified "landscape" risk factors to sea otters for *T. gondii* infections. While Burgess et al. (2018) demonstrate that *T. gondii* oocycts are more prevalent in sea otters in the vicinity of urbanized watersheds, they omitted any mention of the difference in toxicity to sea otters between the *T. gondii* strains that circulate in wild felid versus domestic cat cycles. That is of critical importance because the toxicity of *T. gondii* strains maintained in the wild felid cycle (i.e., bobcats and mountain lions inhabiting undeveloped land) are demonstrably more virulent to sea otters than those in the domestic cat cycle (from urbanized watersheds), as documented by vonWormer et al. (2014). This difference in toxicity was clearly shown in research data published by vanWormer et al. (2014) and summarized in Figure 1 of Shapiro et al. (2019b): in cases where sea otters died from toxoplasmosis, all of them died from type X strain rather than the domestic cat strains typically found in and near urbanized areas. As pointed out by Lafferty (2015), the type X strain and undeveloped lands that harbor it are the primary risk factor to Southern sea otters, rather than urban areas.

These findings confirm that sea otters have been exposed to *T. gondii* infections spread by wild felids in the sylvatic cycle (one that favors high virulence) for a very long time (i.e., as long as 1.5 million years as it spread via wild felids into North America). And second, while domestic cat strains from urban and agricultural areas are found in sea otters, these strains are of low to intermediate virulence and are not the responsible agent for recent sea otter mortalities.

C.1.1.4) The implications for sea otters.

1) Exposure of sea otters to type X strains of *T. gondii* comes primarily from the shedding of oocysts by wild felids (bobcats and mountain lions) rather than domestic cats.

2) Natural selection favors the maintenance of clonal, non-virulent, or less virulent strains of *T. gondii* in domestic cat populations, regardless of the (limited) spillover from wild felids to domestic cats. Data and modeling results indicate that, with regards to *T. gondii* virulence affecting sea otters, natural selection is more likely than not to maintain genotypic proportions and the sea otters' situation is unlikely to worsen. When near urban areas, otters are less likely to be infected by wild type X *T. gondii* due to natural selection.

3) As concluded by Lafferty (2015), "[a]lthough many [scientific] papers and the popular press purport that human actions put sea otter health at risk, these parasites are a natural, long-standing problem for sea otters." Notwithstanding this refutation and new data discussed above, the popular press has continued the inaccurate narrative, for example: *Parasite Spread by House Cats Is Killing California's Sea Otters*.[46]

4) Annual census data show that the Southern sea otter population has experienced an overall increasing trend over the past several decades despite ongoing *T. gondii* infection (California Department of Fish and Wildlife 2019; Hatfield et al. 2019).

5) *T. gondii* infections are not unique to sea otters, and like other mammals, the data do not show that they are population limiting.

---

[46] https://www.smithsonianmag.com/smart-news/parasite-spread-house-cats-killing-californias-sea-otters-180973014/ - C0sB7k05BrZAFFLu.99.

6) Sea otters, as well as other mammals, have likely experienced *T. gondii* infections spread by wild felids in the sylvatic cycle for a very long chapter of evolutionary history, and more recently by less virulent or avirulent domestic cat strains.

Fortunately for Southern sea otters and other wildlife affected by feral cat populations, a revolutionary new method of fertility control for domestic cats with a single intramuscular injection has been developed and published in the scientific journal *Nature Communications*. That treatment utilizes an adeno-associated viral vector that delivers an anti-Müllerian hormone transgene, producing long-term contraception in female domestic cats and inducing loss of pregnancy (Vansandt et al. 2023; Godin et al. 2025; Stocker et al. 2025). This new method will allow sterilization of large numbers of feral female cats, quickly and efficiently, in contrast to the current labor-intensive method of capture, surgically sterilize, hold until recovered, and release back into the wild.

C.1.2) *Sarcocystis neurona.*

Similar in life history to *T. gondii*, *Sarcocystis neurona* (*S. neurona*) is found in a broad range of terrestrial and marine mammals including sea otters, harbor porpoises, harbor seals, Steller sea lions, Guadalupe fur seals, Northern elephant seals, Northern fur seals, pygmy sperm whales, Pacific white-sided dolphins, opossums, raccoons, skunks, armadillo, cattle, horses, domestic cats, and Canadian lynx (Dubey et al. 2015; Lafferty 2017). The definitive hosts of *S. neurona* are the Virginia opossum (*Didelphis virginiana*) and South American opossum (*D. albiventris*) (Barbosa et al. 2015). After ingestion or vertical transmission (mother to offspring), the parasite encysts in muscle cells of intermediate hosts without causing apparent clinical symptoms, and may cause encephalomyelitis if it migrates into the central nervous system. Not all opossums are infected, and frequency of infection varies regionally (5.9% in Central California to 9.4% in northwestern Washington; Rejmanek et al. 2009; O'Byrne et al. 2019).The degree of virulence also varies, which is relevant to understanding its effect on Southern sea otters. These patterns are explained by the parasite's simple population structure whereby asexual reproduction can occur in the opossum's gut and lead to locally acquired, clonal lineages. It is generally assumed, based on similar life history to *T. gondii*, that the definitive host, the Virginia opossum, sheds the infective stage of the parasite on land, which then enters the marine environment through freshwater runoff.

In 2004, a mass mortality event of Southern sea otters in Morro Bay (n=40), caused by *S. neurona*, raised concerns about the parasite infecting more sea otters. However, subsequent research has shown that this was due to one virulent strain with a unique genotype not found elsewhere (Miller et al. 2010). Other otters, infected with different strains of *S. neurona*, survived with chronic infections (based on IgM and IgG titers, DNA PCR detection, and histopathology). As noted by Miller et al. (2010), "[s]imilar to *T. gondii* infections of marine species (Miller et al., 2004), strain-specific variations in parasite prevalence, infectivity and pathogenicity may prove to be important in the ecology of *S. neurona* infections of marine mammals." Additionally, "[a]lthough opossums are common in California, the terrestrial-to-marine flow of fecal waste from these animals is probably patchy and episodic, entering the ocean through multiple point-source discharges from rivers and stormwater drainages interspersed along the shore." *S. neurona* is not a range-wide threat to Southern sea otters but an episodic, local one.

C.2) White shark predation.[47]

Sea otters are not the Southern California coastal ecosystem's apex predator. That position belongs to white sharks. Therefore, as otters have increased their numbers and expanded their range and habitat use, it should come as no surprise that sharks increasingly take otters. This represents the return of a mechanism of natural population regulation that ceased to exist after sea otters were nearly extirpated from the California coast and sharks were apparently at lower density (California Department of Fish and Wildlife 2014). As concluded by Tinker et al. (2016):

> [A] number of lines of evidence indicate that sea otters are at carrying capacity throughout the center portion of their range (Laidre et al. 2001, Tinker et al. 2008, Thometz et al. 2014), and thus range expansion and growth at the northern and southern peripheries of the range will be critical for further recovery (USFWS 2012). Unfortunately, the range peripheries are the very areas where the recent increase in shark mortality has been greatest.

Shark predation means expectations as to the rate of otter population increase need to be adjusted in view of the return of otters and sharks to the near-shore coastal ecosystem. While shark bite mortality does occur, it has not caused the Southern sea otter population to decline. Also, the extent to which the white shark population or sharks' aggregations near shore have changed over the past decade is unclear, as the most recent published data are from 2012 (Miller et al. 2020) and 2017 (Nicholson et al. 2018). Several facts are, however, certain. First, elephant seal colonies at the northern and southern range extent are food sources for white sharks and are primarily where shark predation occurs, rather than the center of the range where otter population density is highest. Second, sharks do not actually prey on and consume otters; rather, shark bites on sea otters occur when sharks explore otters as potential prey items. Third, stranding data from Table 2 of Miller et al. (2020) reveal that male otters are more susceptible to shark bite mortalities across all age classes than female otters because males venture further offshore. Thus, the impact on population productivity is not proportional to the overall level of shark bite mortalities. Currently, no information indicates that the Southern sea otter's continued existence is threatened by current white shark predation (Tinker et al. 2021b). On the contrary, the Southern sea otter population has continued to increase despite the uptick in shark bite mortalities through 2017.

D. Inadequacy of existing regulatory mechanisms.[48]

State protections for the Southern sea otter

If the Southern sea otter is delisted as a threatened species under the Endangered Species Act, it will continue to be protected under California law. More specifically, California recognizes the sea otter both as a fully protected mammal (Cal. Fish & Game Code § 4700) and as a protected marine mammal (Cal. Fish & Game Code § 4500). A fully protected mammal may not be taken or possessed at any time unless the CDFW authorizes the taking for necessary scientific research, including efforts to recover such a fully protected species. Public notification of such

---

[47] Updated data and information, from Petitioners' 2021 petition and 09.14.2023 Science Update.

[48] Data and information from Petitioners' 2021 petition.

authorization is required through the California Regulatory Notice Register, and public comments must be considered.

If delisted, funding for research, habitat conservation and other management activities will continue. For example, since 2006, a California tax check-off has typically provided annual contributions above $250,000 to the *California Sea Otter Fund*, the proceeds of which are split between the California Department of Fish and Wildlife (CDFW) and the State Coastal Conservancy to benefit the Southern sea otter. CDFW and the Coastal Conservancy use the Sea Otter Fund to support informative scientific research and fund conservation efforts to protect and increase the Southern sea otter population. Donations are made via tax forms to the Rare and Endangered Species Preservation Program and/or the California Sea Otter Fund.[49]

Federal regulations may block the otter's continued recovery

The Service's regulatory actions have exacerbated this problem. In 1986, Congress allowed the Service to translocate otters to San Nicolas Island to establish an additional population. Pub. L. No. 99-625 (1986). To get fishermen and others who use surrounding waters to agree, Congress conditioned this authority on an exemption under the Endangered Species Act and MMPA for incidental take in a zone surrounding the introduced population. 132 Cong. Rec. S17321-22 (Oct. 18, 1986).

Translocating otters proved more difficult than the Service estimated, leading it to introduce only half the anticipated number of otters. 77 Fed. Reg. 75,266, 75,280 (Dec. 19, 2012) (139 otters introduced out of the 250 permitted). Consequently, the population was initially smaller than expected. Three years into the program, the San Nicolas Island population fell eight otters short of the Service's goal. 77 Fed. Reg. 75,287–88.[50] However, it has since expanded considerably. In 2019, 121 otters were observed on San Nicolas Island, having sustained a nearly 10% annual growth rate for the previous decade. USGS, *California Sea Otter (Enhydra lutris nereis) Census Results, Spring 2019* 5.[51] Unfortunately, the Service terminated the protections afforded fishermen and others under Public Law No. 99-625, based on the population missing the three-year goal decades earlier. 77 Fed. Reg. 75,266.[52]

If establishing additional otter populations in the San Francisco Bay or other locations becomes advisable, the unjust treatment of the fishermen and others who agreed to Public Law No. 99-625's compromise would serve as a significant obstacle. Any other stakeholder considering whether to cooperate with the Service would have little confidence that the Service will uphold

---

[49] www.wildlife.ca.gov/tax-donation and www.facebook.com/seaotterfundcdfw

[50] If the population goal were adjusted in proportion to the number of otters actually transported, the San Nicolas Island population would have exceeded the 1990 target. The Service only released 56% of the 250 otters allowed under the program. Despite this, the 1990 population was nearly 70% of the Service's goal.

[51] https://pubs.usgs.gov/ds/1118/ds1118.pdf

[52] Petitioners challenged that decision, arguing that Congress gave the Service no authority under Public Law No. 99-625 to terminate these protections once it established the population. The Ninth Circuit upheld the decision, reasoning that the statute's silence on whether the Service has such authority should be deemed an implicit delegation under *Chevron v. NRDC*. *See California Sea Urchin Commission v. Bean*, 883 F.3d 1173 (9th Cir. 2018).

its end of the bargain even if, as on San Nicolas Island, the project resulted in a successful otter population.

E. Other natural or man-made factors affecting the population’s continued existence.

E.1) Oil spills: Why predictions based on hypothetical, worst-case oil spill and climate change scenarios do not constitute best available science.[53]

The issues identified below raise the following question: Should the Service be basing regulatory and recovery decisions on analyses of extreme, worst-case scenarios with a remote possibility of occurring? Moreover, should those decisions assume multiple, extreme value, worst-case, remote possibility scenarios occurring simultaneously as the Service (2023) did in their SSA?

E.1.1) Hypothetical, worst-case crude oil spills.

As the centerpiece of their threat analysis of oil spills on Southern sea otters, the authors of the SSA (2023) utilized analyses by Tinker (2021), who modeled several hypothetical oil spill scenarios. The authors of the SSA (2023) subsequently combined those hypothetical impacts with the hypothetical impact of an extreme climate change scenario. These models and their outputs assumed:

A) a highly unlikely, worst-case, unmitigated *Exxon Valdez*-scale crude oil tanker spill of ten million gallons (and separately, a “medium” sized spill of one million gallons);

B) the hypothetical oil tanker spill will occur in one of four locations: (two worst-case scenario locations (southwest of San Francisco) in terms potential impact to sea otters, and two less-impactful locations west of Point Conception); and

C) the spill occurs in 2037 alongside a worst-case RCP8.5 climate change scenario (even though the RCP8.5 is no longer considered realistic by the International Panel on Climate Change (IPCC[54])).

The assumptions behind each of these worst-case scenarios ignore the current, best available regulatory, scientific, and commercial data, as described below. Furthermore, by assuming that all three worst-case, low-probability scenarios occur simultaneously, the results exaggerate current and future threats to Southern sea otters. Taken collectively, the analysis and discussion of oil spill threats in the SSA represents partial and inaccurate presentation of information to decision makers to justify the continued threatened listing of Southern sea otters.[55]

---

[53] New data and information, unique to this petition.

[54] https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf

The RCP8.5 is so unrealistic that it assumes that all recent climate policies and technological progress worldwide are abandoned and oil and gas consumption are overtaken by a five-fold increase in coal burning.

[55] https://www.federalregister.gov/documents/2023/09/20/2023-20296/endangered-and-threatened-wildlife-and-plants-one-species-not-warranted-for-delisting-and-six

E.1.2) Modern oil tanker operations: Tinker's (2021) and the SSA's (Service 2023) hypothetical oil tanker spill locations are inconsistent with current oil tanker operations and established shipping lanes.

What is the probability of a tanker spill of 10 million gallons occurring in the specific areas used by Tinker (2021) and subsequent SSA analyses? No offshore drilling exists in the areas used in Tinker's oil spill modeling, thus catastrophic spills from oil rigs can be ruled out.

The two "high risk areas" and selected oil tanker spill locations within these areas in the analysis by Tinker (2021, Figure 1 and Table 1) appear to be of his own invention: one south of the Farallon Islands/west of San Francisco, and the other west of Point Conception off the Southern California coast. However, nautical charts (NOAA 2024)[56] and U.S. Coast Guard websites reveal that Tinker's (2021) so-called "high risk areas" do not exist. In contrast, there are much smaller "Precautionary Areas" close to harbor entrances. These areas are where multiple shipping lanes converge and where harbor pilots are picked up and disembark.[57] These Precautionary Areas begin approximately 10 miles off the San Francisco Bay entrance and Los Angeles/Long Beach harbors. In contrast, Tinker's (2021) hypothetical "high risk areas" are farther from the coastline and, in the case of the "San Francisco spill risk area," are chosen as the worst possible location for a catastrophic oil spill for the Southern sea otter population.

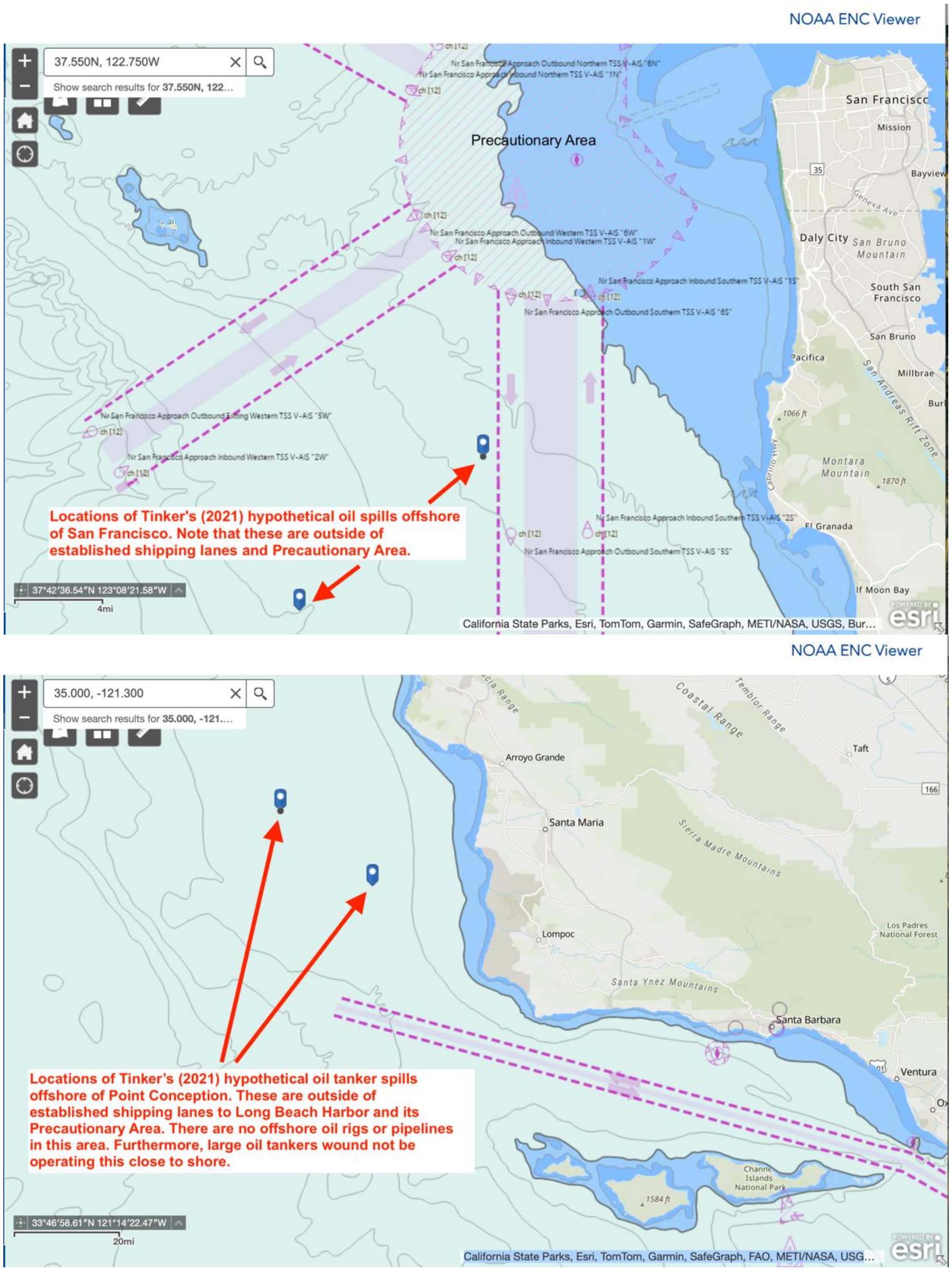
By plotting Tinker's (2021) hypothetical oil tanker spill locations, all the spills are well outside of shipping lanes established by the U.S. Coast Guard and International Maritime Organization. That alone makes them improbable oil tanker spill locations (see figures below). The hypothetical spill locations used by Tinker (2021) are incongruent with established standards dictating that large Alaskan crude oil tankers remain over 50 nautical miles off the California coast to minimize the chance of oil spills in near-shore waters. Additionally, large crude oil tankers destined for the San Francisco Bay and Long Beach harbors approach via the deep water, western approach shipping lanes or the southern shipping lane in the case of Los Angeles/Long Beach Harbor,[58] thus avoiding more congested near-shore shipping lanes. And finally, no offshore oil platforms or pipelines exist in the two "high risk areas" of their hypothetical spill locations.

---

[56] https://nauticalcharts.noaa.gov/publications/coast-pilot/files/cp7/CPB7_WEB.pdf; https://nmsfarallones.blob.core.windows.net/farallones-prod/media/archive/eco/vesselstrikes/media/uscg_flyer.jpg

[57] https://www.ecfr.gov/current/title-33/chapter-I/subchapter-P/part-167/subpart-B

[58] https://www.ecfr.gov/current/title-33/chapter-I/subchapter-P/part-167/subpart-B/subject-group-ECFRe56bee97182a298/section-167.500



Locations of Tinker's (2021) hypothetical oil spills offshore of San Francisco. Note that these are outside of established shipping lanes and Precautionary Area.

Locations of Tinker's (2021) hypothetical oil tanker spills offshore of Point Conception. These are outside of established shipping lanes to Long Beach Harbor and its Precautionary Area. There are no offshore oil rigs or pipelines in this area. Furthermore, large oil tankers wound not be operating this close to shore.

Figures 3a and 3b. Locations of Tinker's (2021) oil spill locations off San Francisco and Point Conception, California. Figures were produced using the mapping tool https://nauticalcharts.noaa.gov/enconline/enconline.html.

Based on the above-mentioned discrepancies, Tinker (2021) and the USFWS (2023) Species Status Assessment authors must be unfamiliar with modern oil tanker operations and Coast Guard shipping lanes designed to reduce collision risk. It appears that the hypothetical oil tanker spill locations used by Tinker (2021) were either arbitrarily selected, or, in the case of hypothetical spill locations southwest of San Francisco, potentially selected to maximize hypothetical impacts to southern seas otters (i.e., where the currents would transport the maximum amount of oil from those hypothetical locations to the greatest length of coastline occupied by Southern sea otters).

E.1.3) Tinker's (2021) worst-case oil tanker spill scenario is inconsistent with current data and regulations.

The sheer scale of the Tinker (2021) and the SSA's hypothetical 10 million-gallon, *Exxon Valdez*-scale oil tanker spill is not consistent with recently published data on oil tanker spills. Data show that these spills have dramatically decreased in size and frequency over recent decades, especially in U.S. waters[59] (Figure 4, below). These decreases occurred because of regulatory and technological improvements designed to increase tanker safety and oil spill response following the 1989 *Exxon Valdez* oil spill. Those safety improvements were extensively detailed in Petitioners' 2021 delisting petition.

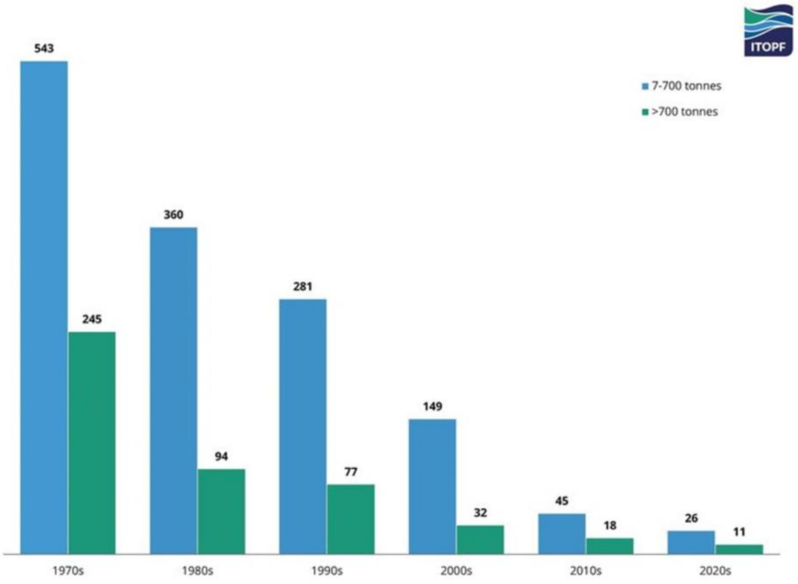


Figure 2: Number of medium (7-700 tonnes) and large (>700 tonnes) tanker spills by decade, 1970 - 2024
*Only 5 years of data available for the 2020s

Figure 4. Worldwide oil tanker spill statistics by decade. Data from ITOPF.org.

As an initial matter, oil tankers are no longer the single-hulled vessels that were vulnerable to catastrophic failure from the slightest hull damage, as occurred with the *Exxon Valdez*. In that incident, 8 of its 11 tanks ruptured, spilling 37,000 tonnes of crude oil (over 11 million gallons), when it ran aground on Bligh Reef in Prince William Sound, Alaska.[60] The *Exxon Valdez* was an outdated single-hull tanker design with minimal safety measures.

Following the 1989 *Exxon Valdez* oil spill and the 1990 *American Trader* oil spill south of Long Beach, the California legislature passed the Oil Spill Prevention and Response Act of 1990

---

[59] https://www.itopf.org/knowledge-resources/data-statistics/oil-tanker-spill-statistics-2024/

[60] https://evostc.state.ak.us/oil-spill-facts/details-about-the-accident/

(Chapter 1248, Stats.1990; commonly referred to as SB 2040) and the U.S. Congress passed the Oil Pollution Act of 1990 (33 U.S.C. §§ 2701–2761 and other related sections). Passage of these laws, and regulations adopted by the European Union and International Maritime Organization, had the combined effects of phasing out all single-hulled oil tankers by 2010. After 2010, all oil tankers had to be double-hulled and are required to have: duplication of navigational equipment and steering gear; inert gas systems to prevent fires in oil storage tanks; towing arrangements with fixtures fore or aft on hulls to facilitate towing at sea in the event of engine failure; placement of water ballast tanks to protect main tanks in the event of grounding or collision; enhanced inspections to detect supertanker safety deficiencies including corrosion, wear and tear, and hull girder strength; and the carriage of automatic identification systems (AISs) that provide continuous information about the ship and its location to other ships and to coastal authorities.[61]

In addition to these measures, the following have been implemented:

- *Traffic Separation Schemes* were designed by the U.S. Coast Guard in 2000, and have been periodically revised to establish internationally recognized shipping lanes where opposing flows of ship traffic are separated by buffer zones;
- *Areas to be Avoided* were established to ensure that cargo-carrying ships avoid the Channel Islands National Marine Sanctuary;
- *NOAA Whale Advisory Zones* and *10-knot-or-less voluntary speed limits* on the approaches to San Francisco Bay to the north (Cordell Bank to Half Moon Bay) and approaches to the Los Angeles/Long Beach Harbor;
- *US Coast Guard Vessel Traffic Information Services* that are analogous to air traffic controllers;
- *Precautionary Areas* near harbor entrances;
- *Harbor Safety Committees*;
- *Modeling tools* developed by NOAA that allow for the prediction of oil spill surface and subsurface transport and fate, providing decision-makers with a range of options for oil recovery actions and response strategies; and
- Coast Guard and NOAA compilation of data on oil spills into U.S. waters.

E.1.4) Liability for oil spill clean-up, as well as criminal and civil liabilities, are powerful economic incentives that have also contributed to oil tanker safety.

Finally, Petitioners note the strong economic incentives for owners of oil tankers operating in U.S. coastal waters to prioritize increased safety to avoid liability for oil spills and their cleanup costs. Additional cleanup costs, fines, settlements and legal fees drive initial estimates even higher. For example, in the *Exxon Valdez* oil spill, Exxon settled in 1991 with funds including a:

---

[61] Please refer to Petitioners' 2021 Petition for additional detailed information.

criminal plea agreement ($25 million), criminal restitution ($100 million), and civil settlement ($900 million). Additionally, Exxon claimed that it spent $2.1 billion on the cleanup effort.[62] Estimates of the spill's total cost vary but appear to have been at least $4 billion.[63] In 2025 dollars, due to inflation alone, that estimated total cost would exceed $8 billion. Therefore, it should come as no surprise that increasing regulation, technological improvements to oil tanker safety, and economic considerations have substantially decreased the volume and frequency of oil spills in U.S. coastal waters since the 1989 *Exxon Valdez* oil spill. Viewed from this perspective, a crude oil spill of 10 million gallons in the year 2037, as conjectured by Tinker (2021) and the Service in their 2023 SSA, is an extremely remote possibility.

E.1.5) Tinker's (2021) hypothetical catastrophic oil spill simulations did not include any spill response and mitigation.

The Tinker (2021) and SSA (Service 2023) analyses did not account for oil spill response and mitigation measures to contain and disperse any spill, thereby reducing its overall impact. The Tinker (2021) simulations simply assumed that the oil would drift unmitigated into coastal waters occupied by sea otters, which is unrealistic in U.S. waters.

E.2) The Service's use of a worst case, highly unlikely climate change scenario coupled with a worst case, highly unlikely oil spill scenario does not constitute best available science.[64]

E.2.1) Implications of the Service's use of the RCP8.5 climate scenario in their SSA analyses, with and without catastrophic oil spills.

The SSA utilized the highly unlikely, worst-case RCP8.5 climate change scenario to center their analysis of *Potential Future Conditions* affecting the Southern sea otter population. Although the SSA also utilized a moderate RCP4.5 climate scenario, the highly unlikely worst-case RCP8.5 was used in two of the three hypothetical scenarios presented. One of those RCP8.5 scenarios was coupled with a hypothetical, worst-case crude oil spill on the coast of California (discussed below).

Petitioners further note that the May 25, 2025, White House Executive Order, *Restoring Gold Standard Science*, singled out the National Marine Fisheries Service's erroneous use of the RCP8.5 worst case climate scenario in population projections for the North Atlantic right whale, in a biological opinion that could have destroyed the historic Maine lobster fishery.[65]

Representative Concentration Pathways (RCPs) refer to four possible climate scenarios by the end of the century (RCP2.6, RCP4.5, RCP6.0, and RCP8.5) used by the International Panel on

---

[62] https://evostc.state.ak.us/oil-spill-facts/q-and-a/

[63] https://www.itopf.org/in-action/case-studies/exxon-valdez-alaska-united-states-1989/

The International Tanker Owners Pollution Federation Limited (ITOPF) is a not-for-profit organization established on behalf of the world's ship owners to promote effective responses to marine spills of oil, chemicals, and other hazardous substances.

[64] New data and information, unique to this petition.

[65] https://www.whitehouse.gov/presidential-actions/2025/05/restoring-gold-standard-science/

Climate Change (IPCC) in their 2014 IPCC Fifth Assessment Report. The numbers associated with each of these RCPs reflect the additional radiative forcing (in watts per square meter) due to greenhouse-gas emissions in 2100, relative to pre-industrial times (1750). The higher radiative forcing the higher global warming. The current radiative forcing is approximately 2.5 watts per meter squared.

The differences between the RCP4.5 and the RCP8.5 are substantial. Most importantly, RCP4.5 represents a realistic scenario where emissions rise until 2040 then begin to fall and are halved by 2100, with resultant warming of approximately 2–3°C. In contrast, the RCP8.5 assumes global temperature rise of 4–7°C (7.2–14.4 °F) by 2100 due to sharply increasing greenhouse gas emissions, with no CO_2 reductions whatsoever, and the equivalent of a five-fold increase in coal consumption. The International Panel on Climate Change considered this unlikely in their *IPCC Sixth Assessment Report, Working Group 1: The Physical Science Basis* (IPCC 2022)[66]:

> The uncertainty range on assessed future changes in global surface temperature is narrower than in the AR5. For the first time in an IPCC assessment cycle, multi-model projections of global surface temperature, ocean warming and sea level are constrained using observations and the assessed climate sensitivity. The likely range of equilibrium climate sensitivity has been narrowed to 2.5°C to 4.0°C (with a best estimate of 3.0°C) based on multiple lines of evidence, including improved understanding of cloud feedbacks. [Petitioners' emphasis added].

Similar findings have been reported in these two prominent scientific journals: *Nature* by Hausfather and Peters (2020)[67] and *The Proceedings of the National Academy of Sciences* by Burgess et al. (2022).[68]. More recently, Sarofim et al. (2024) published a probabilistic analysis of the RCP8.5 scenario, putting the scenario's likelihood below one percent (0.53%).[69]

Unfortunately, despite these refutations, the RCP8.5 continues to be used by authors of documents, such as the SSA, without understanding that the assumptions that went into it in 2005 are outdated and no longer realistic. Hausfather and Peters (2020) provide a graphic example of this issue with exaggerated impacts from relying on RCP8.5 for analyses.

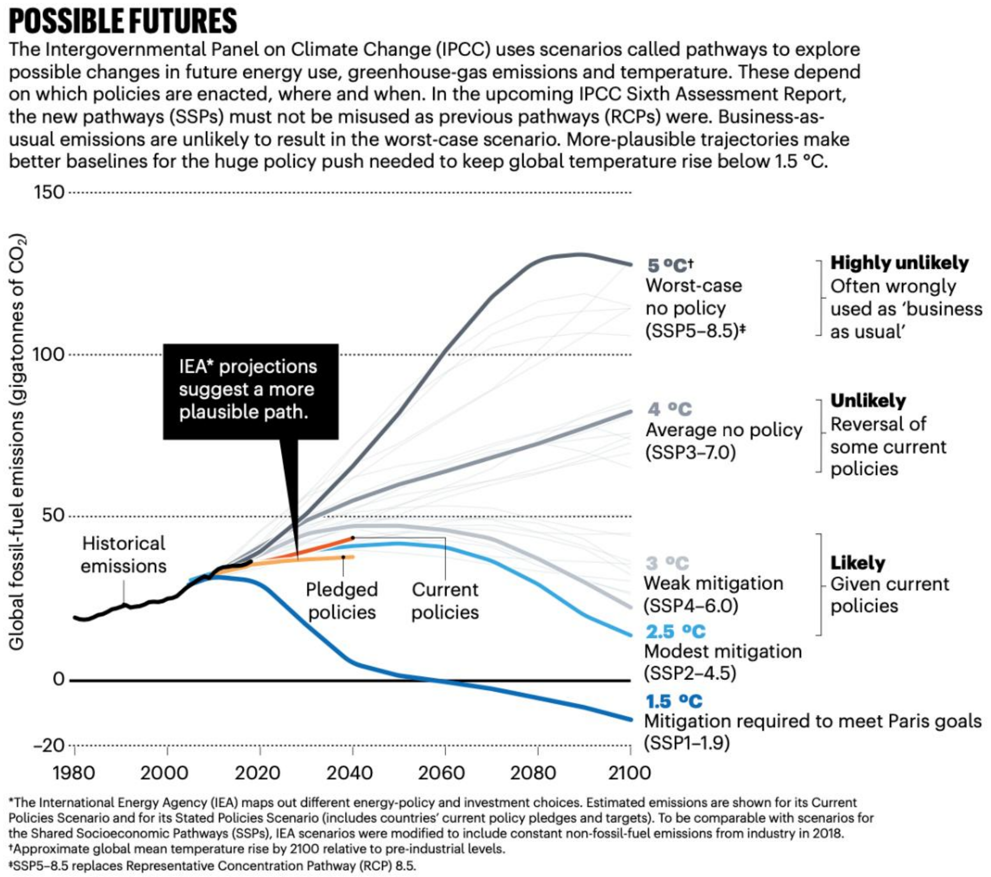
---

[66] IPCC (2022) IPCC Sixth Assessment Report, Working Group 1: The Physical Science Basis. https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-1/.

[67] Hausfather Z, Peters GP (2020) Emissions – the 'business as usual' story is misleading. Nature 577, 618-620. doi: https://doi.org/10.1038/d41586-020-00177-3.

[68] Burgess MG, Pielke R Jr, Ritchie J. (1) Catastrophic climate risks should be neither understated nor overstated. Proc Natl Acad Sci U S A. 2022 Oct 18;119(42):e2214347119. doi: 10.1073/pnas.2214347119

[69] Sarofim, M.C., Smith, C.J., Malek, P. *et al.* High radiative forcing climate scenario relevance analyzed with a ten-million-member ensemble. *Nat Commun* 15, 8185 (2024). https://doi.org/10.1038/s41467-024-52437-9.



POSSIBLE FUTURES

The Intergovernmental Panel on Climate Change (IPCC) uses scenarios called pathways to explore possible changes in future energy use, greenhouse-gas emissions and temperature. These depend on which policies are enacted, where and when. In the upcoming IPCC Sixth Assessment Report, the new pathways (SSPs) must not be misused as previous pathways (RCPs) were. Business-as-usual emissions are unlikely to result in the worst-case scenario. More-plausible trajectories make better baselines for the huge policy push needed to keep global temperature rise below 1.5 °C.

*The International Energy Agency (IEA) maps out different energy-policy and investment choices. Estimated emissions are shown for its Current Policies Scenario and for its Stated Policies Scenario (includes countries' current policy pledges and targets). To be comparable with scenarios for the Shared Socioeconomic Pathways (SSPs), IEA scenarios were modified to include constant non-fossil-fuel emissions from industry in 2018.

†Approximate global mean temperature rise by 2100 relative to pre-industrial levels.

‡SSP5–8.5 replaces Representative Concentration Pathway (RCP) 8.5.

Figure 5. Plots of modeled IPCC climate change scenarios trajectories in terms of global fossil fuel emissions and their relative probabilities ("likely," "unlikely" and "highly unlikely") based on International Energy Agency projections. Note the RCP8.5 "worst-case" climate scenario (uppermost curve) being ranked as "highly unlikely." This figure was adapted from Hausfather and Peters (2020) as published in the scientific journal *Nature*.

E.2.2) Arbitrarily inflated climate change impacts to Southern sea otters are not "best available science." In the absence of data, the best available science is not speculation.

In their "analysis" of climate change impacts under the RCP8.5 scenario, the SSA arbitrarily assumed extreme, unrealistically uniform, across-the-board 30% decreases in Southern sea otter population carrying capacity, 30% increases in direct mortalities, and 30% increases in the frequency and intensity of factors potentially leading to increased mortality. By comparison, the RCP4.5 scenario assumed across-the-board impacts of 10%.

Without any supporting data or quantitative explanation, the SSA simply assumed the RCP8.5 climate scenario would result in a 30% decrease in population carrying capacity due to an increase in: adult female mortality from end-lactation syndrome (apparent moralities due to the high energetic cost of reproduction), and Acanthocephalan peritonitis (due to an intestinal parasite that naturally infects sea otters).[70] Furthermore, the SSA simply assumed the RCP8.5 climate scenario would result in the following unrealistically uniform impacts:

- a 30% increase in shark bite mortality;
- a 30% increase in both the frequency and severity of harmful algal blooms that result in domoic acid poisoning events;
- a 30% increase in protozoal infection (i.e., toxoplasmosis and sarcocystosis); and
- a 30% increase in "infection (other)" – This is a hypothetical, climate-driven impact the SSA attributes to a "*possible introduction of novel pathogens* into the nearshore environment." In other words, a hypothetical increase in a threat by an unnamed, hypothetical pathogen.

Not only is the RCP8.5 an unrealistic, worst-case climate scenario, but the Service used it in the SSA to justify their use of hypothetical 30% decreases in population carrying capacity and 30% increases in mortalities from climate change in population models. Then, on top of those impacts, the Service piled on impacts from a hypothetical *Exxon Valdez*-scale oil spill in the worst possible location to impact Southern sea otters (outside of shipping lanes, offshore of San Francisco).

Not surprisingly, the Service reported in the SSA that the RCP 8.5 scenario and the "RCP 8.5 + Large Oil Spill scenario" resulted in substantial Southern sea otter population decreases over 50 years (i.e., 30–33% decreases by 2071). However, the RCP4.5 climate change scenario resulted in a mean increase in population size of 16%, a result the SSA downplayed. Excerpts of those results in the SSA are provided below:

> Under the **RCP 8.5 scenario**, the mean abundance of sea otters in 50 years was 2,075 (1,205–3,091), **a 30% decrease** from the estimated starting population size of 2,975 independent animals in 2022.
>
> Under the **RCP 8.5 + Large Oil Spill scenario**, the mean abundance of sea otters in 50 years was 1,992 (1,144–2,946), **33% smaller** than the estimated starting population size of 2,975 independent animals in 2022.
>
> Under the **RCP 4.5 scenario**, the mean abundance of sea otters in 2071 was 3,454 (1,849–5,408), a **16% increase** from the estimated starting population size of 2,975 independent animals in 2022.

And finally, contrary to their own results in Table 6 of the SSA (see Figure 8 for subpopulation locations), the Service states that results of the RCP4.5 scenario "indicate no range expansion to the north but some range expansion to the south relative to current conditions in 2022." Conversely, the results in that table show the mean projected number of otters in each of the five subpopulations north of their current range to be between 12 and 156. Those results are as

---

[70] Acanthocephalans are thorny-headed worms which infect the intestinal tract of sea otters.

follows: Marin n=35 (range 0-125), Drakes Estuary n=12 (range 0-41), San Francisco Bay n=130 (range 0-410), and Half Moon Bay n=156 (range 0-389). However, the Service attempts to explain away such positive results capriciously by considering those subpopulations as having an "unknown" status because the 80% credible intervals for estimates included zero, regardless of their use of mean estimates that contain zeros elsewhere in the SSA.

E.2.3) The probability of a worst case RCP8.5 climate scenario occurring and an *Exxon Valdez*-sized oil spill occurring near San Francisco during the summer of 2037 is vanishingly small.

The combined probability of the RCP8.5 climate scenario and a catastrophic oil spill off the central California coast is vanishingly small because it relies on two unlikely events occurring simultaneously. However, an estimate of this combined probability can be calculated using the best available scientific and commercial information available. That is, the product of: (1) the probability of a catastrophic oil spill occurring in Tinker's (2021) "San Francisco Spill Risk Area" based on the approach developed by Ji et al. 2014, 2021[71] at the Bureau of Ocean Energy Management (BOEM) and (2) the probability of the RCP8.5 climate scenario occurring, as published by Sarofim et al. (2024).[72]

BOEM estimated an annual 0.6% chance[73] of a catastrophic oil spill (1 million barrels) somewhere in the entire BOEM Outer Continental Shelf Planning Area of 1.68 billion acres (6,798,719 km^2). Therefore, the annual probability of a hypothetical spill occurring somewhere within Tinker's (2021) "San Francisco Spill Risk Area" of approximately 4,675 square kilometers is proportional to the total BOEM OCS Planning area: or (4,675 km /6,798,719 km) x 0.6, which equals 0.00041 (or 0.41 thousandths of one percent chance of occurrence).

As noted above, Sarofim et al. (2024) estimated that the chance of a RCP8.5 climate scenario occurring is 0.53%. Therefore, the combined probability of both the RCP8.5 and Tinker's (2021) hypothetical, unmitigated, worst-case oil spill occurring off San Francisco is approximately 0.00041 x 0.0053 = 0.00000220, or two millionths of one percent chance.

With such a vanishingly small probability of occurrence, it becomes unclear why the Service used this "analysis" of hypotheticals as a centerpiece in the Species Status Assessment (USFWS 2023) and its "not warranted" decision on the 2021 delisting petition.

---

[71] https://www.boem.gov/environment/how-boem-calculates-oil-spill-risk

[72] Sarofim, M.C., Smith, C.J., Malek, P. *et al.* High radiative forcing climate scenario relevance analyzed with a ten-million-member ensemble. *Nat Commun* 15, 8185 (2024). https://doi.org/10.1038/s41467-024-52437-9

[73] Ji, Z.-G.; Li, Z.; Johnson, W.; Auad, G. Progress of the Oil Spill Risk Analysis (OSRA) Model and Its Applications. J. Mar. Sci. Eng. 2021, 9, 195. https://doi.org/10.3390/jmse902019. The authors acknowledge that this risk will continue to decline with additional safety technologies and regulatory measures designed to reduce the oil spills size and frequency.

E.2.4) Oil spills: why the overall threat of major oil spills within the range of the Southern sea otter has dramatically reduced.[74]

When the Service listed the Southern sea otter ESA in 1977, the threat of a substantial tanker or super-tanker oil spill at the northern and southern extent of otter core range was a hazard likely to increase in the years to follow (U.S. Fish and Wildlife Service 1977). In 1977, the United States depended upon oil imports. Oil tankers were single-hulled, without redundant steering systems, and were navigated by traditional means (i.e., pre-GPS navigation era). Oil tankers and many other vessels operated with little environmental oversight. It was also a time, following the 1973–1974 OPEC oil embargo, that the size of oil tankers was increasing as a result of demand and the economy of scale: from typical 30,000–50,000 deadweight (DWT) tankers to supertankers of 100,000–550,000 DWT, the latter capable of carrying up to 4.2 million barrels of oil (Alcock 1992; Spyrou 2011). The threat of a large-scale tanker-related oil spill occurring from navigational error, mechanical failure, accidental collision, grounding, fire, tanker-to-shore pipeline accident, or sinking was an increasing concern. To the Service in 1977, such an event appeared highly probable (U.S. Fish and Wildlife Service 1977).

In 1977, the probability of a tanker-related oil spill in the remaining Southern sea otter population's range was increased because there were two offshore oil tanker offloading facilities and one offshore oil tanker loading facility in operation. On the northern extent of the sea otter range, there was an offshore oil unloading facility at Moss Landing, for tankers of up to 50,000 DWT.[75] There were also multiple large (up to 2.5 million gallon) storage tanks located onshore to fuel the Moss Landing electrical power plant. Simultaneously, proposals emerged to expand the capacity of deepwater unloading facilities at Moss Landing for supertankers to provide crude oil to proposed oil refineries that would require 50,000 barrels of oil daily from offshore tanker deliveries (Battelle 1973; U.S. Fish and Wildlife Service 1977). Moss Landing, at the mouth of Elkhorn Slough, contained the largest remaining population of Southern sea otters and, therefore, was a particularly sensitive location.

At the southern extent of the sea otter range, oil tankers were regularly unloading at an offshore mooring to provide fuel to the Morro Bay electrical power plant.[76] Similar to Moss Landing, the powerplant stored oil in a near-shore tank farm adjacent to the powerplant.

Between Moss Landing in the north and Morro Bay in the south, an oil tanker terminal extended offshore at Estero Bay. That facility had exported crude oil from Kern County and the Kettleman Hills since the 1920's and was also proposed to be scaled up into a supertanker port for larger exports.[77]

---

[74] Updated data and information from Petitioners' 2021 petition.

[75] https://montereybay.noaa.gov/intro/mp/archive/original_eis/partII_sIII.html

[76] https://www.slc.ca.gov/wp-content/uploads/2018/09/MND-4.pdf

[77] U.S. Fish and Wildlife Service 1977; https://www.newtimesslo.com/sanluisobispo/say-goodbye-to-the-chevron-marine-terminal/Content?oid=2944553; and https://www.morro-bay.ca.us/DocumentCenter/View/513/LCP-Chapter-VII-Energy_Industrial-Development?bidId=.

E.2.4.1) The closing of offshore crude oil loading and unloading facilities at Moss Landing, Estero Bay, and Morro Bay eliminated the major threat to the Southern sea otter of a near-shore tanker or supertanker oil spill.

Market forces and air quality regulations resulted in the Moss Landing and Morro Bay electrical power plants being converted from oil-fueled to natural gas-fired plants by 1995. The secondary benefit from these conversions was the elimination of oil spill hazards associated with oil tankers supplying these facilities via offshore pipelines. The Morro Bay plant officially closed in 2014, and the offshore unloading facilities and pipelines were decommissioned and removed in 2019.[78] The Moss Landing power plant is being converted to an electrical storage facility, using banks of utility-grade lithium-ion storage batteries and previously removed former oil storage tanks. Lastly, the Estero Bay oil tanker-loading facility became obsolete and ceased operations in 1999 with the construction on the inland Pacific Pipeline that transferred crude oil directly to Los Angeles refineries.[79] The Estero Bay pipelines and onshore tank farm were subsequently removed in 2011.

The threat of an oil spill endangering the Southern sea otter has passed. Substantial changes have occurred in oil tanker design, navigational technology, regulation, oil spill response, and liability, as well as market forces and regulations that resulted in both oil phase-outs at the Moss Landing and Morro Bay electric generating facilities and closure of the Estero Bay offloading facility. While oil spills do occur at sea, the trend has decreased in both number and volume (U.S. Coast Guard 2011). Presently, the threat of oil spills at a magnitude that could potentially endanger the Southern sea otter population has become highly unlikely.

E.2.4.2) Post *Exxon Valdez* regulatory changes and new technologies to improve oil tanker safety further reduced the oil spill threat to the Southern sea otter.

Ironically, two major tanker-related oil spills in 1989 and 1990 were largely responsible for global changes to oil tanker operations that dramatically increased their safety. After the 1989 *Exxon Valdez* oil spill in Alaska's Prince William Sound and the 1990 *American Trader* oil spill south of Long Beach, California, regulatory steps were taken to substantially reduce the risk of oil tanker spills in coastal waters. First, the California legislature passed the Oil Spill Prevention and Response Act of 1990 (Chapter 1248, Stats. 1990; commonly referred to as SB 2040). Second, the U.S. Congress passed the Oil Pollution Act of 1990 (33 U.S.C. §§ 2701–2761 and other related sections). Due to this legislation, actions were implemented to increase vessel safety, improve vessel traffic control, and prevent tanker-related oil spills off the California coast and within California ports.

Most significantly, the Oil Spill Prevention and Response Act of 1990 phased out single-hulled tankers in U.S. waters. The Act required all new oil tankers to be double-hulled, and older single-hulled tankers to be phased out starting in 1995 with the final date for phase out in 2015. This date was subsequently moved up to 2010. In 2007 the European Union (EU) mandated all oil

---

[78] https://longitude123.net/l123_home/featured-project/

[79] http://historicalmorrobay.org/wp-content/uploads/2019/06/STANDARD-OIL-AND-ESTERO-BAY.pdf

tankers be double-hulled to use EU ports or to drop anchor in their territorial waters. And finally, the International Maritime Organization (the United Nations agency for shipping) implemented a similar phase out of all single-hulled tankers by 2010 (Stenman 2005), as well as other mandatory safety requirements specific to oil tankers, including: duplication of navigational equipment and steering gear; inert gas systems to prevent fires in oil storage tanks; towing arrangements with fixtures fore or aft on hulls to facilitate towing at sea in the event of engine failure; placement of water ballast tanks to protect main tanks in the event of grounding or collision; enhanced inspections to detect safety deficiencies including corrosion, wear and tear, and hull girder strength; and automatic identification systems (AISs) that provide continuous information about the ship and its location to other ships and coastal authorities.[80] The AIS system is a safety measure that allows ship captains to identify all vessels, see their direction of travel in surrounding waters, and establish radio communications with them as needed to avoid collisions.

E.2.4.3) Regulations have improved vessel traffic control in the Southern sea otter's range, minimizing the probability of an oil spill.

Vessel traffic control has been recognized as a key step to reduce the risk of vessel mishaps off the California coast or within California ports. The following safety measures have been implemented offshore:

- *Traffic Separation Schemes* have been designated to direct offshore vessel traffic along portions of the California coastline including the Santa Barbara Channel. Analogous to air traffic lanes, these are internationally recognized vessel routing designations which separate opposing flows of vessel traffic into lanes and include a buffer zone between lanes (U.S. Coast Guard 2000).[81]

- *Areas to be Avoided* (ATBA) have been established to restrict movement of tankers and barges carrying oil as cargo. The ATBA off the Southern California coast requires that all cargo-carrying ships avoid the Channel Islands National Marine Sanctuary unless those ships are bound to ports at one of the sanctuary's islands.[82]

- *NOAA Whale Advisory Zones* and 10-knot-or-less speed limits reduce the risk of ships striking whales and the probability of ship-to-ship collisions. These are current voluntary speed restrictions, along with coastal Traffic Separation Schemes and shipping lanes, on the approaches to San Francisco Bay to the north (Cordell Bank to Half Moon Bay) and to the Los Angeles/Long Beach Harbor in the south (Dana Point to Pt. Arguello). These are posted on regularly updated NOAA navigation charts and alerts.[83]

---

[80] http://www.imo.org/en/OurWork/Safety/Regulations/Pages/OilTankers.aspx; *see also* http://www.oilspillprevention.org/oil-spill-sources/ships.

[81] Chart available at https://charts.noaa.gov/PDFs/18720.pdf and https://charts.noaa.gov/PDFs/18700.pdf.

[82] Chart available at: https://charts.noaa.gov/PDFs/18720.pdf.

[83] https://www.navcen.uscg.gov/pdf/lnms/lnm11252019.pdf, see pages 38-39.

- *Vessel Traffic Information Services* are in operation in the Ports of Los Angeles/Long Beach and San Francisco Bay to monitor traffic within harbors and approaches, helping prevent accidents that could result in oil spills.[84]

- *Precautionary areas* were designated in congested areas near harbor entrances to set speed limits, prescribe vessel routing, or establish other safety precautions.[85]

- *Safety fairways* have been established to prohibit the permitting and placement of structures such as oil platforms between a port and the entry into a Traffic Separation Scheme.[86]

- *Harbor Safety Committees* were established for the harbors of San Diego, Los Angeles/Long Beach, Hueneme, San Francisco, and Humboldt. These committees have developed harbor safety plans for each port and identified key safety issues for resolution by the California Office of Spill Prevention and Response.[87]

Collectively, the changes described above have significantly reduced the potential for a major oil spill along California's coastal areas inhabited by the Southern sea otter.

Many of these regulatory measures have also carried over to the international shipping industry where annual shipping losses (i.e., spills and sinkings) worldwide have fallen by more than 65% over the past decade—from 132 in 2009 to 46 in 2018, and are now at their lowest level this century (Allianz 2019).

E.2.4.4) Offshore oil rigs do not threaten Southern sea otters because of improved regulations, technology, and industry practices.

The 1969 Santa Barbara Oil Spill from Platform A in the Santa Barbara Channel off of Southern California occurred in the early years of minimally-regulated offshore drilling, with practices that would be unacceptable, if not illegal, today. Most notably, the drill casing used was inadequate to contain the pressures encountered (causing the sea floor to fracture near the surface and release additional oil) and there was no blowout preventer installed on the wellhead during the blowout (Clarke and Hemphill 2002; Wheeling and Ufberg 2017; Pinkston and Flemings 2019). Moreover, there were no oil spill contingency plans, no agency responsible for directing clean-up, no accepted clean-up procedures, and no mandated liability. Since then, the situation has changed.

Oil spills of 1,000 gallons or more from ships, offshore platforms, and pipelines in all U.S. waters combined have decreased from 842 in 1974 to 24 in 2011. Smaller spills of 101–1,000 gallons have decreased from 1,457 to 117 in the same time period (U.S. Coast Guard 2011). The notable exception to these trends was the Deepwater Horizon/Macondo exploratory well spill in the Gulf of Mexico during 2010. However, that spill, like the Exxon Valdez tanker spill of 1989,

---

[84] https://www.navcen.uscg.gov/?pageName=vtsLocations

[85] https://inport.nmfs.noaa.gov/inport/item/39986

[86] https://inport.nmfs.noaa.gov/inport/item/39986

[87] http://oilspilltaskforce.org/ourwork/harbor-safety-committees-best-maritime-practices/ and https://wildlife.ca.gov/OSPR/Marine-Safety/Harbor-Safety.

led to extensive investigations into contributing causes (National Research Council 2012; U.S. Chemical Safety and Hazard Investigation Board 2016; Pinkson and Flemings 2019) and substantive improvements in technology, industry practices, and regulatory oversight by the Coast Guard, the Department of Interior's Bureau of Safety and Environmental Enforcement, and Bureau of Ocean Energy Management (Bureau of Safety and Environmental Enforcement 2016, 2019a,b). Regulations improving the safety of offshore operations include the Drilling Safety Rule (Oct. 2010), Safety and Environmental Management Systems (SEMS I) in October 2010, and SEMS II in April 2013. Subsequently, the Department of Interior's Bureau of Safety and Environmental Enforcement (BSEE) published the Blowout Preventer Systems and Well Control final rule (the WCR) on April 29, 2016, and the Oil and Gas and Sulfur Operations in the Outer Continental Shelf-Blowout Preventer Systems and Well Control Revisions, effective July 15, 2019 (Bureau of Safety and Environmental Enforcement 2019a,b).

Concurrently, four Joint Industry Task Forces (JITFs) were assembled to focus on critical areas of offshore activity: (1) the Joint Industry Offshore Operating Procedures Task Force, (2) the Joint Industry Offshore Equipment Task Force, (3) the Joint Industry Subsea Well Control and Containment Task Force, and (4) the Joint Industry Oil Spill Preparedness and Response Task Force. These task forces,

> brought together Industry experts to identify best practices in offshore drilling operations and oil spill response; with the definitive aim of enhancing safety and environmental protection. The ultimate goal for these JITFs is to improve well containment and intervention capability, spill response capability, and industry drilling standards to form comprehensive safe drilling operations; not only through evaluation and revision of Industry guidelines and procedures, but also active engagement with regulatory processes. (American Petroleum Institute 2015).

Collectively, new regulations and industry safety initiatives increased safety standards for well design, well control, and blowout preventers while adapting to more refined technologies and industry practices including operations off the Southern California coast. Additionally, only 27 offshore platforms remain and several are being plugged, decommissioned, and slated to become part of the Rigs-to-Reefs program (Bull and Love 2019).

Petitioners note that there is a fundamental difference in operational safety and oil spill risk between deep water and shallow water offshore oil and gas platforms because shallow water platforms, such as those off Southern California, are easier to inspect and service. At the southernmost extent of Southern sea otter range, platforms are drilled in water 120 to 300 feet deep, compared to deepwater wells like the Deepwater Horizon/Macondo well drilled in water 5,000 feet deep. Using analysis of incident data and water depth, Muehlenbachs et al. (2013) reported that "each 100 feet of added depth increases the probability of a company-reported incident by 8.5%." Industry sources report similar data (Institute for Energy Research 2010). Collectively, scientific and commercial data indicate the risk of a catastrophic oil spill from offshore oil and gas operations at the southern extent of the Southern sea otter's range has greatly decreased in the last decade. Thus, oil spills do not threaten the Southern sea otter's continued existence in the foreseeable future.

E.2.4.5) Modeling the fate of oil spills.

Modeling tools provided by NOAA enable the prediction of oil spill surface and subsurface transport and fate, providing decision-makers many options for oil recovery actions and response strategies. These include the use of chemical dispersants to enhance dilution in open water and increase biodegradation, thus reducing shoreline impacts (National Research Council 2005; Bejarano and Mearns 2015). The General NOAA Oil Modeling Environment (GNOME) is the most widely used of these modeling tools.[88] None of these modeling tools existed at the ESA listing in 1977, and none have been mentioned by the Service in their 2003 Recovery Plan or most recent status review.

In contrast to the above scientific data, commercial data, and regulatory policies, the 2015 five-year status review stated that, "[d]espite significant advances in techniques for washing oiled sea otters made during the last 20 years at the CDFW's Marine Wildlife Veterinary Care and Research Center, it is clear that a spill of sufficient magnitude to cause population-level effects would overwhelm the capacity of rehabilitators to rescue sea otters and return them to the wild." In support, the status review's authors cited an obsolete 2002 ship collision study that was conducted before AIS location transmitter systems were required (West Coast Offshore Vessel Traffic Risk Management Project Final Project Report and Recommendations July 2002).[89] Despite that omission, the status review's authors concluded that increased tanker and ship traffic would occur between the San Francisco and Los Angeles Harbors and surmised that this would increase the probability of a catastrophic oil spill having a population level effect on Southern sea otters. A single oil spill event in 2007 releasing 53,569 gallons of fuel oil in the San Francisco Bay after a ship struck the San Francisco Bay bridge (outside the Southern sea otter range) was cited as proof that oil spills could occur and kill large numbers of sea otters. However, no mention was made of the U.S. Coast Guard response and subsequent clean-up. Similarly, no data on the history, frequency, size, or hazards of oil spills along the Southern sea otter range was presented.

The example above illustrates the speculation published in the sea otter literature and regulatory documents regarding a hypothetical, worst-case oil spill in the Southern sea otter range that could threaten the population (e.g., Hughes et al. 2019). However, the most recent USCG compendium on oil spills into U.S. waters reveals how significantly oil spills have diminished, especially in California waters (inland and coastal combined): in 2011, 159 spills occurred, with a total volume of 3,900 gallons, a maximum spill size of 990 gallons, and an average spill size of 24.5 gallons.

E.3) Climate change.

Speculation exists about the effects of climate change on Southern sea otter food resources and population trends (*see* U.S. Fish and Wildlife Service 2015, 2017). However, no reliable predictions of trends resulting from climate change into the reasonably foreseeable future currently exist.

---

[88] https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/response-tools/gnome-suite-oil-spill-modeling.html

[89] http://library.state.or.us/repository/2010/201007070951103/index.pdf

As an initial matter, there is difficulty in determining the relative contributions of long-term non-anthropogenic global warming trends (i.e., Holocene warming) and trends resulting from anthropogenic inputs (i.e., greenhouse gases). Next, it is problematic to make long-term predictions of regional climatic trends (e.g., along coastal waters of Southern California) because of decadal and intra-decadal variation caused by the Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO). The most recent IPCC report on *Observed Climate Variability and Change* notes that "[o]n decadal time-scales, the Pacific Decadal Oscillation (PDO) and the related Inter-decadal Pacific Oscillation (IPO) may account for approximately half the global mean variation in surface temperatures." Graphic examples of this variation's extent and frequency may be seen at the Joint Institute for the Study of Atmosphere and Ocean[90] and in Figure 2.29, of Folland et al. (2001) ("El Niño-La Niña variations from 1876 to 2000 measured by sea surface temperature in the region 5°N to 5°S, 150 to 90°W."). Reliably quantifying these potential interactions is equivocal, as reported by Folland et al. (2001):

> There is ambiguity about whether inter-decadal Pacific-wide features are independent of global warming. In the longer Folland et al. (1999) analyses since 1911 they appear to be largely independent, but in the Livezey and Smith analysis of more recent SST [sea surface temperature] data they are an integral part of a global warming signal. Using a different method of analysis of data since 1901, Moron et al. (1998) find a global warming signal whose pattern in the Pacific is intermediate between these two analyses.

An additional problem is identifying and quantifying (with reasonable certainty) specific cause-and-effect mechanisms that could link predictions of coastal water temperatures and weather patterns to observed sea otter vital rates and demography.

Petitioners note that, to date, not even the most simplified effects hierarchy of factors affecting Southern sea otter abundance has been proposed.

Compounding these issues is the localized population structure of Southern sea otters, where "*processes that regulate population abundance (including density-dependent resource abundance) also occur locally*," rather than range-wide (Tinker et al. 2019). These can also shift over time. In other words, there is local heterogeneity in the factors that affect Southern sea otters, making simplified, range-wide predictions problematic, if not impossible.

Taken collectively, the implications of these issues are clear: predicting long-term sea otter population trends into the foreseeable future based on long-term, broad-scale global model predictions is an exercise fraught with uncertainty. And as discussed above, when climate change impacts on sea otters are based on the discredited, worst-case RCP8.5 scenario and arbitrarily inflated impact values for RCP8.5 (or RCP4.5), uncertainty is replaced with erroneous speculation. That is precisely why the 2023 Species Status Assessment's analysis of *Potential Future Conditions* does not have a sound scientific basis.

---

[90] http://research.jisao.washington.edu/pdo/

E.4) Human influence on the coastal environment.[91]

The final conclusions of Tinker et al.'s (2019) 225 page compilation of 15 years of research summarizes the data, results, and their significance to the Southern sea otter population's status: *Southern sea otter population biology at Big Sur and Monterey, California—Investigating the consequences of resource abundance and anthropogenic stressors for sea otter recovery* (see Chapter 11. Synthesis and Conclusions).[92] Tinker's conclusions are powerful and compelling because they were based upon hypothesis testing against empirical data, in the tradition of strong inference in science (Popper 1957; Platt 1964).

Testing of these four hypotheses is important because they have served as working hypotheses for over ten years, guiding the interpretation of research, policy, and management of Southern sea otters. However, like all scientific hypotheses, they can be tested with new data. Hypotheses whose predictions are inconsistent with the data are rejected, while those consistent with the data are provisionally accepted and used to revise and guide future research and adaptive management. In the Southern sea otter's case, three of four working hypotheses were not supported by empirical data. Therefore, as noted by Tinker (2019), the results require "*a reevaluation of some of our assumptions about factors driving trends in sea otter abundance in central California*."

Because the Tinker study represents the best available science on sea otter abundance, and discredits the analytical lens favored by prior researchers, Petitioners present the General Conclusions of Tinker (2019) below, along with our clarifications [in brackets]:

> The various modules of the Big Sur-Monterey population study reported in the preceding chapters represent the culmination of one of the most expansive studies of sea otter biology ever conducted. The breadth of topics covered and the diversity of results are complex, and distilling all this information down to a few simple conclusions is no easy task. All the analyses presented in this report were conducted with the aim of testing one or more of the primary hypotheses, often using multiple lines of inquiry. Considered together, the various lines of investigation encompassed by this study generally were consistent with respect to their degree of support (or lack of support) for each of the four primary hypotheses, as described here.
>
> 1. **Sea otters living in areas adjacent to human population centers and areas heavily impacted by runoff or sewage (for example, Monterey) are more likely to be exposed to pathogens and toxins of public health importance than those in more pristine areas (for example, Big Sur)**. This hypothesis was *not supported* by the results of our study. An epidemiological analysis of *Toxoplasma gondii* infections (chapter 9) indicated that sea otters in the highly impacted site were significantly *less* likely to be exposed than were otters from the pristine area. Necropsies of study animals that died during the study indicated that the frequency of the domoic acid exposure (a biotoxin produced from diatom blooms) as a contributing cause of death was approximately equal between the two study sites (occurring in 50-percent of recovered carcasses at Big Sur

---

[91] Updated data and information, from Petitioners' 2021 petition.

[92] https://doi.org/10.3133/ofr20191022

and 44-percent of recovered carcasses at Monterey; chapter 10). Gene expression analysis indicated no significant differences between sites in patterns indicative of physiological responses to pathogens or toxins, with the exception of elevated response to organic contaminants in sea otters from Big Sur in 2008 (possibly due to effects of Big Sur wildfires that year; chapter 3). We did not conduct laboratory tests of blood contaminant levels, owing to funding constraints (although blood samples have been archived to permit such analyses in the future), so we cannot rule out the possibility that there may have been differences in exposure to specific contaminants that were consistent with this hypothesis; however, physical exams and blood diagnostic tests showed no evidence of health effects that would suggest such a pattern, and the minor differences in health parameters that were reported indicated more abnormalities in sea otters from Big Sur, the pristine site (chapter 2).

2. **Patterns of survival and causes of death will differ between heavily impacted and pristine environments, indicating differences in pathogen and toxin exposure**. This hypothesis was *not supported* by our results. The comprehensive analysis of sea otter survival and weaning success showed that sea otters from the pristine site (Big Sur) had lower age-specific survival rates than did sea otters from the heavily impacted (Monterey) study site, and female weaning success rates showed a similar pattern (chapter 8). These differences were explained almost entirely by the differences in resource abundance and body condition of animals at the two sites; after controlling for the effect of age-specific body mass, there were no significant differences in survival rates between the two sites. In terms of causes of death of study animals (chapter 10), necropsies indicated that the same suite of causal factors were evident at both sites in roughly equal proportions, with the exception of boat strikes which only occurred at the Monterey site (2 out of 9 cases). [To clarify, only two cases of suspected (not confirmed) mortality due to boat strike were documented over the four years and nine months of the study.]

3. **Environmental risk factors will vary between sites, corresponding to the differing land-use patterns**. This hypothesis was for the most part *not supported* by our results, with some important caveats. As discussed in hypothesis 1, the health assessments (chapter 2) and gene expression analyses (chapter 3) suggested no consistent differences in environmental risk factors, with the exception of up-regulation of certain genes in sea otters captured at Big Sur in 2008 suggestive of increased exposure to organic contaminants. [Those organic contaminants were attributed to runoff from two unusually large wildfires along Big Sur in 2008: the 66,500 ha Basin fire (caused by lightning strike) and the 6,240 ha Chalk fire (cause unknown) based on Bowen et al. (2015). Such one-off stochastic events are not indicative of long-term trends in exposure to fire-related organic contaminants. Gene transcript profiles were found to return to baseline levels the following year. Any long-term health effects on the sea otters are purely speculative.] Epidemiological analysis (chapter 9) indicated that exposure to the protozoal parasite *Toxoplasma gondii* was significantly greater at Big Sur than at Monterey. Thus, our results indicate variation in environmental stressors across sites, and over time; however, the differences were not clearly attributable to differences in human population densities or land-use patterns. [To state the results more precisely, *T. gondii* infection of otters is not correlated with human population densities or land-use patterns.

The predominant *Toxoplasma* strain along Big Sur is the wild type X strain and its closely related variants. Type X strain is virulent to sea otters and is part of a natural *T. gondii* cycle in wild felids (bobcats and mountain lions). Strains of *T. gondii* associated with the domestic cat cycle are of comparatively low virulence to otters and were found near Monterey.]

4. **Sea otters from high-density populations (and [or] areas that have been occupied longer) will have lower rates of foraging success compared to sea otters from low-density populations (and [or] areas that have been more recently occupied) due to prey resource depletion, and these patterns will be indicated by (a) greater percentage of time spent feeding, (b) more pronounced individual diet specialization, (c) poorer body condition, and (d) lower survival rates of adults and pups**. This hypothesis was *well supported* by data collected in the current study and in previous similar studies. Sea otters at Big Sur and Monterey study sites (both of which have supported high-density populations for many years) had relatively low rates of energy gain while feeding as compared to low-density, growing populations in California, Washington, British Columbia, Alaska, and Russia (chapter 6). Big Sur sea otters had slightly lower energy intake rates than did otters in Monterey, and also spent slightly more time feeding (chapter 5) and had slightly greater levels of diet specialization (chapter 6), although these latter metrics were high at both sites as compared to low-density populations. A comparison of body condition and survival rates across six sites in California (chapters 7 and 8, respectively) showed that lower foraging success in high-density sea otter populations was indicated by poorer body condition and decreased survival, and pup weaning success rates, with strongly significant correlations among all of these parameters.

Based on the hypothesis tests described here, not all of our predictions were supported by empirical datasets, requiring a reevaluation of some of our assumptions about factors driving trends in sea otter abundance in central California. The enormous scope and inter-disciplinary nature of this project, and the extensive sample sizes available from both the current study and from previous similar studies conducted over the past 15 years, allow us to update our understanding of Southern sea otter population biology. Four general conclusions about the sea otter populations of central California, and the factors driving trends in abundance, have emerged from this work:

1. Density-dependent population regulation driven by per-capita resource abundance is the most significant factor currently limiting population growth in the center part of the range (approximately from the Monterey Peninsula to Estero Bay). [The otter population along the central coast is naturally self-limiting. As the otter density increases to carrying capacity, food resources are depleted, competition increases, and population growth rate slows. This is not a threat to the population and it can be expected to occur in other areas as otters expand their range.]

2. Spatial and temporal variation in environmental and anthropogenic stressors also can affect sea otter health, based on previous research (for example, Miller and others, 2002; Johnson and others, 2009; Miller and others, 2010), but patterns of variation are complex and are not simply a function of proximity to human populations. [It would be more

accurate to characterize the patterns as discernable rather than "complex" because the cause and effect mechanisms, operating at local scales over short time periods, are easily understood by those with a basic understanding of ecology and evolutionary biology.]

3. Exposure to environmental stressors (either natural or anthropogenic in origin) does not act independently of resource limitation. [In other words, environmental stressors such as disease or exposure to wildfire runoff have a more pronounced effect on individual otters where they are food-limited. This occurs along the Big Sur coast where the population density and competition for food resources is highest.]

4. Sea otter populations are structured at small spatial scales, and the processes that regulate population abundance (including density-dependent resource abundance) also occur locally. [In other words, sea otters tend to remain in their natal areas or local home ranges and are naturally reluctant to disperse into unfamiliar areas. And because local environmental conditions, as well as risk factors, can differ among sites and over time, it should come as no surprise that productivity, survivorship, and population growth rates also differ among sites. The significance of that finding is that there is no data suggesting the existence of a single (i.e., range-wide) threat of consequence to the southern sea otter's persistence.]

II. Alternatively, the Service should issue a rule under Section 4(d) of the Endangered Species Act to provide relief to fishermen and other water users and to encourage further recovery efforts

If the Service determines the Southern sea otter does not yet merit delisting, Petitioners ask, alternatively, that the Service issue a rule under Section 4(d) of the Endangered Species Act and to restore the protections guaranteed to fishermen and others under the latter statute range-wide. Such a tailored approach is advisable because of significant improvements in the species' overall status and specifically the San Nicolas Island population. It would also reduce conflicts that could otherwise hamstring the Service's ability to implement additional recovery efforts for the sea otter, including establishing additional populations by translocation.

In August 2019, the Service revised its regulations for prohibitions to threatened species, recognizing that tailoring regulations to individual species' needs better promotes species recovery and is fairer to the regulated community. 84 Fed. Reg. 44,753 (Aug. 27, 2019). However, this reform only applies to species listed as threatened after September 26, 2019. *Id.* For species listed earlier, like the Southern sea otter, blanket take prohibitions continue to apply. This revised regulation was rescinded on April 5, 2024 but is proposed for reissuance. 89 Fed. Reg. 23919 (Apr. 5, 2024); 90 Fed. Reg. 52587 (Nov. 21, 2025).

Under Section 4(d) and the recent reform, the Service should regulate take of threatened species only to the extent "necessary and advisable" for the species' conservation. 16 U.S.C. § 1533(d). This is a broad standard, but some factors the Service must consider are clear. First, what are the conservation benefits to the species, if any, of regulating particular instances of take? Second, what costs are imposed on the Service, the regulated community, and other environmental goals? *See Michigan v. EPA*, 576 U.S. 743, 752 (2015) (broad standards like "necessary and advisable" require consideration of costs because "[o]ne would not say that it is even rational, never mind ‘appropriate,’ to impose billions of dollars in economic costs in return for a few dollars in health or environmental benefits”).

These factors counsel in favor of restoring Public Law No. 99-625’s exemption and extending it range-wide. First, the conservation benefit to the species of forbidding this incidental take is small. Less restrictive regulations can greatly reduce any harms commercial fishing might otherwise cause. Indeed, existing regulations likely already serve this purpose. In the 1970s and 1980s, the sea otter population declined because of entanglement with fishing gear. 2003 Recovery Plan at viii. However, California adopted regulations to address this concern and “the population immediately began to increase again.” *Id*. Likewise, the Service has concluded that incidental take by commercial fishermen has not prevented other otter populations from growing rapidly. *Id.* (discussing otter populations in Alaska, Washington, and Canada).

Indeed, tailoring the take regulation for the Southern sea otter would have conservation benefits and create necessary goodwill for further recovery action. Rewarding fishermen and others for their role in the species’ progress to date with relaxed regulations will incentivize further actions for this and other species. *See* 84 Fed. Reg. at 44,755 (explaining that “regulatory relief” under Section 4(d) is anticipated to incentivize conservation); Jonathan Wood, *The Road to Recovery: How Restoring the Endangered Species Act’s Two-Step Process Can Prevent Extinction and Promote Recovery*, PERC Policy Report (2018) (explaining that gradual reduction of regulation as threatened species recover would best align the regulated parties’ incentives with the interests of rare species).[93] Indeed, this approach has already proven effective on the Southern sea otter. Exemptions from incidental take regulation under Public Law No. 99-625 secured the cooperation of fishermen and others in establishing the San Nicolas Island population, which has contributed significantly to the species’ recovery over the last decade. USGS, *California Sea Otter (Enhydra lutris nereis) Census Results, Spring 2019* 5.[94]

By contrast, regulation costs are high. For every other species regulated under the Endangered Species Act and Marine Mammal Protection Act, federal agencies have broad discretion to issue permits authorizing incidental take, thereby reducing the costs imposed on the regulated community. However, Public Law No. 99-625’s exemptions are the exclusive means of approving incidental take affecting the California sea otter. *See* 16 U.S.C. § 1387(a) (authorizing permits for incidental take of any marine mammal except for the California sea otter and cross-referencing Public Law No. 99-625).[95]

The Service’s 2012 decision to terminate the exemption assumed these costs would be minor because the San Nicolas Island population would not expand in the foreseeable future. 77 Fed. Reg. at 75,292. That prediction has not borne out. Instead, the San Nicolas Island population has sustained a 10% annual growth rate during the last decade and likely will expand into the surrounding fishery. USGS, *California Sea Otter (Enhydra lutris nereis) Census Results, Spring 2019* 5.[96] Indeed, otters may have already migrated from San Nicolas Island to other Channel Islands or the mainland. USGS, Press Release, *Annual Southern Sea Otter Survey: Despite Small*

---

[93] https://www.perc.org/wp-content/uploads/2018/04/endangered-species-road-to-recovery.pdf

[94] https://pubs.usgs.gov/ds/1118/ds1118.pdf

[95] Public Law No. 99-625 also exempts incidental take from regulation under the Marine Mammal Protection Act.

[96] https://pubs.usgs.gov/ds/1118/ds1118.pdf

Population Dip, Species Moves a Step Closer to Recovery (Sept. 29, 2017).[97] In any event, and in consideration of the lack of any authority to otherwise permit incidental take, the Service should consider all costs incurred as sea otters expand into other fisheries.[98]

III. Request for a moratorium on additional Southern sea otter translocations.

The Petitioners further request a moratorium on additional translocations of Southern sea otters. Southern sea otters should not be artificially translocated to the northern coast of California, San Francisco Bay, and Channel Islands, but should be allowed to recolonize naturally and on their own.[99]

A. Socio-Economic Reasons: The loss of fisheries.

Translocating Southern sea otters to the northern coast of California, San Francisco Bay, and Channel Islands will negatively impact recreational and commercial shell fisheries. That will, in turn, harm local economies and longstanding traditions of earning a living from the sea.

A.1) Assertions that shellfisheries and local economies could offset losses from the impacts of sea otter translocations by converting to sea otter tourism rely on three unfounded assumptions:

1. fisheries and their boats can easily transition to sea otter tourism;
2. sea otter tourism can expand indefinitely without market saturation and subsequent loss of value; and
3. economic analyses of successful sea otter tourism operations from prime tourism destinations such as Monterey Bay somehow applies to small, out-of-the-way towns and cities along the northern coast of California without tourism infrastructure.

A.2) If otter translocations proceed along the Northern California coast, skilled urchin divers with local, working-knowledge of subsurface topography and conditions will likely be displaced from the area due to economic losses (from being out-competed by translocated otters for red urchins, a preferred food of otters). Based on case studies and preliminary economic modeling, economic losses for urchin divers are inevitable. However, if urchin divers and their equipment become unavailable, plans for utilizing urchin divers to remove purple urchins for aquaculture and to aid kelp recovery will fail.

A.3) Sea otter translocations along the Northern California coast, San Francisco Bay, and Channel Islands are proposed without plans to manage local population sizes, prevent over-consumption of endangered abalone, or address conflict with commercial and recreational dive fisheries. This will inevitably lead to conflicts with conservation of other marine species and

---

[97] https://www.usgs.gov/news/annual-southern-sea-otter-survey-despite-small-population-dip-species-moves-a-step-closer

[98] Indeed, if the Service minimizes these costs by assuming few or no incidental takes will occur, this would also necessarily mean the prohibition would provide no or minimal benefits to the species. Consequently, the costs and benefits would continue to weigh in favor of restoring the exemption.

[99] New data and information, unique to this petition.

people who depend upon the sea for a living. However, there is no mention of sea otter population management in the Service's Sea Otter Reintroduction Assessment. Without a planned population management program, sea otter populations along the California coast can be expected to expand to carrying capacity and will increasingly compete with fisheries for red urchins and Dungeness crab.

A.4) Petitioners are concerned that if translocations occur, the Service would then consider each translocated and native subpopulation as a separate "recovery unit." Each of these recovery units would have its own numerical objective and all recovery units would be required to exceed those numerical objectives for at least five to ten years before delisting could be considered, regardless of overall population number. Thus, any potential delisting could be extended far into the future, further damaging fisheries. A similar "recovery unit" strategy has allowed the Service to keep the Peninsular Bighorn Sheep Distinct Population Segment listed for nearly two decades despite the overall population reaching its recovery objective in 2006.[100]

B. Otter translocations would further endanger other endangered species.

B.1) Translocating Southern sea otters to the northern coast of California, San Francisco Bay, and Channel Islands will negatively impact endangered populations of black abalone[101] and white abalone.[102] The translocation will also harm the declining populations of northern (pinto) abalone[103] and red abalone.[104] Along the Northern California coast, sea otter translocations will likely hinder the recovery of black abalone and efforts to reestablish the species in its historic range. Without intensive management, including sea otter removals, Chades et al. (2012) predicted that northern abalone would decline.[105] In fact, the International Union for Conservation of Nature (IUCN) recently concluded that all west coast species of abalone are at risk of extinction.[106]

B.2) If Southern sea otters are translocated into areas where endangered abalone species exist, it will demonstrate an arbitrary taxonomic preference for recovery priorities by the Service: a sea otter subspecies that is no longer threatened because it has reached its recovery objective would be prioritized over full species of invertebrates that are critically endangered and will be even more endangered following translocations of sea otters into their habitat.

---

[100] *See* Figure 4 in December 2024 Peninsular Bighorn Sheep Aerial Surveys. Memorandum. California Department of Fish and Wildlife. May 23rd, 2025.

[101] https://www.fisheries.noaa.gov/species/black-abalone

[102] https://ecos.fws.gov/ecp/species/4580

[103] https://www.fisheries.noaa.gov/species/pinto-abalone

[104] https://wildlife.ca.gov/News/Archive/california-fish-and-game-commission-extends-red-abalone-recreational-fishery-closure-finds-cesa-listing-of-bear-lake-buckwheat-warranted

[105] https://www.sciencedirect.com/science/article/abs/pii/B9780128149386000087?via%3Dihub

[106] https://marinescience.ucdavis.edu/news/all-west-coast-abalones-risk-extinction-iucn-red-list

C. Translocations of sea otters to the northern coast of California will not restore kelp forests there.

Translocations of Southern sea otters to purple urchin barrens along the Northern California coast will not transform these areas into kelp forests for the reasons listed below.

C.1) First, the dramatic ecological "regime shift" from kelp beds to purple urchin barrens along the Northern California coast occurred because of a "perfect storm" of three unrelated phenomena:

1. Disease-related die-off of sea stars that prey on purple urchins (keeping purple urchins in check).
2. Abnormally warm ocean currents (deleterious to kelp survival and reproduction) that were the result of a marine heatwave, often referred to as "the Blob heatwave," and a strong El Niño during 2014–2016.[107]
3. With little kelp detritus to feed on, purple urchins emerged from deeper waters en masse to feed on what remained of live kelp, eating through the holdfasts that kept the kelp anchored to the seafloor. Subsequently, near-starving purple urchins began to blanket former kelp habitats, subsisting on algae but ready to devour any kelp plants before they could become established. (Note: The California urchin fishery depends upon red urchins, not purple urchins.)

Adding to this problem, starving purple urchins along California's northern coast have little to no commercial value unless they are harvested, transferred to tanks onshore, fed, and grown to marketable size and health. This is an unproven, long-term aquaculture business model.[108] Unfortunately, purple urchin barrens are the new ecological "stable state" along the Northern California coast and many other formerly kelp-dominated coastal ecosystems around the world.[109]

Based on recent scientific literature, such a regime shift is unlikely to revert towards kelp abundance because of sea otter translocations, especially with sea stars at low density and additional ocean warming events expected with climate change (Rogers-Bennett and Catton 2019).[110] While labor-intensive methods used to cull purple urchins (including manual crushing, large-scale quicklime applications,[111] and harvesting live urchins to farm in tanks onshore) can help to bring about a localized reestablishment of kelp, these are limited in area and long-term effectiveness because they do not address the underlying cause of the regime shift from kelp to urchin barrens in the first place.[112]

---

[107] https://www.nature.com/articles/s42003-022-04107-z#Abs1

[108] https://phys.org/news/2022-07-scientists-uncover-urchins-california-kelp.html

[109] https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/ecy.1638

[110] https://www.researchgate.net/publication/323474293_Rise_of_Turfs_A_New_Battlefront_for_Globally_Declining_Kelp_Forests

[111] https://link.springer.com/article/10.1007/s00227-024-04540-0

[112] https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2022.831001/full; https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/ecy.1638

The Service's (2022) Feasibility Assessment on Sea Otter Reintroduction to the Pacific Coast makes no mention of this ecological regime shift or that purple urchin barrens are the new stable state in this ecosystem.[113] Instead, the Service perpetuates a myth that sea otters can help reestablish kelp forests, rather than the established fact that otters can help conserve already established kelp forests only when purple urchin density is low. The Service and SAA ignore that sea otters are not required for kelp forests to exist because, in many regions of the world, coastal kelp forests have existed without sea otters. Those include kelp forests in South America, Southern Africa, Australia, New Zealand, the North Atlantic, and Japan.

C.2) Second, research shows that purple urchins are unpalatable and not eaten by sea otters because they do not contain the caloric content to make the effort worthwhile (Holman et al. 2019).[114] In fact, the 2019 Sonoma-Mendocino Bull Kelp Recovery Plan stated that "[r]eintroduction of sea otters is not considered a viable option at this time; [as] urchin barrens will not support sea otter reintroduction." Therefore, sea otters translocated into those areas will shift their diet to other species, including both endangered species such as white and black abalone and species important to commercial and recreation dive fisheries (red abalone, red urchin, Dungeness crabs, and species like mussels). This diversification of diet is a natural response to a food-poor environment, but it can potentially devastate other species.[115]

C.3) Third, historical data from Cameron (1915)[116] and more recent data from the California Department of Fish and Wildlife[117] and Kelpwatch[118] reveal naturally lower numbers of kelp beds and kelp density along the Northern California coast compared to the Southern California coast, even before the most recent decline. This is because the northern coast features sandy and rocky sediment habitats that "represent substantially poorer substrate for persistent kelp forests due to light-limiting turbidity, sedimentation, or scouring, especially in areas of high wave energy or exposure."[119] These conditions favor the less-dense bull kelp (*Nereocystis luetkeana*) rather than the giant kelp (*Macrocystis pyrifera*)[120] common along the Southern California coast.

The data confirm that habitat for kelp along the Northern California coast is naturally limited. Therefore, the Service and sea otter advocates are unrealistic for assuming that sea otter translocations will bring about a dramatic resurgence of kelp to the Northern California coast.

---

[113] U.S. Fish and Wildlife Service (USFWS). 2022. Feasibility Assessment: Sea Otter Reintroduction to the Pacific Coast. Report to Congress prepared by the U.S. Fish and Wildlife Service, Region 9, Portland, Oregon; and Region 10, Sacramento, California.

[114] Hohman, R., Hutto, S., Catton, C. and F. Koe. 2019. Sonoma-Mendocino Bull Kelp Recovery Plan. Plan for the Greater Farallones National Marine Sanctuary and the California Department of Fish and Wildlife. San Francisco, CA. 166 pp. https://farallones.org/wp-content/uploads/2019/06/Bull-Kelp-Recovery-Plan-2019.pdf.

[115] https://pmc.ncbi.nlm.nih.gov/articles/PMC2206575/

[116] Cameron F. 1915 Potash from Kelp. US Department of Agriculture Report, no 100. (see maps of Kelp Groves of the Pacific Coast and Islands of the United States and Lower California: Northern California kelp bed maps may be found on pages 221-233 and Southern California kelp bed maps beginning on page 234), https://ia801908.us.archive.org/25/items/potashfromkelp00came/potashfromkelp00came.pdf

[117] https://wildlife.ca.gov/Conservation/Marine/Kelp/Monitoring

[118] https://kelpwatch.org/map

[119] Ecography 41: 1751–1762, 2018 doi: 10.1111/ecog.03561

[120] https://marinespecies.wildlife.ca.gov/kelp/the-species/

D. Translocations will put otters at risk.

D.1) Proposals to accelerate Southern sea otter range expansion with translocations would be an ill-advised misdirection of conservation resources due to a long-term ecological "regime shift"[121] from kelp forests to purple urchin barrens along the coast of Northern California. Recent, peer-reviewed research indicates that these urchin barrens, rather than kelp forests, are the new "steady state" in this Northern California coastal ecosystem.[122] Based on the best, independently available scientific information, sea otters likely can be successfully established along most of the Northern California coast due to a lack of kelp. Without dense kelp patches, the habitat for sea otters is marginal, mortalities from white sharks increase sharply, and urchin barrens do not provide adequate food resources for sea otters. Translocating otters into such a situation is inhumane and will create a "population sink" where otter mortality and dispersal rates are high.

D.2) By pushing for a translocation program, the Service and sea otter advocates will put the source population along the Southern California coast at risk through continual removals for translocations. By releasing Southern sea otters into marginal habitat patches, such as those along the Northern California coast, Channel Islands, and urbanized San Francisco Bay, the Service will create a population sink for this subspecies rather than letting otters colonize slowly on their own. Faced with marginal habitat and a shortage of potential mates, sea otters will likely disperse from the release area, as many did during the translocation to San Nicholas Island. In that case, 90% of the otters disappeared or dispersed back to the mainland. Thus, additional source population removals would be needed, resulting in prolonged "take" of the subspecies to bolster failing translocations and, eventually, creating a "population sink." It is therefore also worthwhile to ask if translocating a keystone predator, such as Southern sea otters, into such an impoverished environment is inhumane when the sea otter's population will naturally expand in number and range without additional translocations.

E. A balance of harms approach is needed.

As noted above, doubt exists as to whether sea otters could successfully be translocated to the northern coast of California. In fact, the Service admits in the SSA that "[u]ncertainties often arise with regard to whether nearshore marine systems will be suitable to support a reintroduced population of sea otters due to the negative effects of climate change." However, without any supporting data or analysis, the SSA asserts that, "Our position is that reintroduction would reduce the risk to the species or subspecies associated with climate change." By relying on such opinion instead of data to support sea otter translocations, the Service would be effectively weighing the balance-of-harms in favor of speculative benefits to a threatened species (Southern sea otters) at the expense of other endangered species and human communities that would be harmed by sea otter translocations.

---

[121] Large, persistent, and usually unexpected changes in ecosystems.

[122] Rogers-Bennett, L., Catton, C.A. Marine heat wave and multiple stressors tip bull kelp forest to sea urchin barrens. *Sci Rep* 9, 15050 (2019). https://doi.org/10.1038/s41598-019-51114-y.

F. The Service's 2022 report, *Feasibility Assessment on Sea Otter Reintroduction to the Pacific Coast*, calls for an exhaustive list of additional field studies, habitat modeling, pilot studies, and broader ecosystem goals.

In the Service's own words, below:

> [D]etailed ground-truthing of proposed reintroduction sites would be recommended before any reintroduction proceeded. Ground-truthing would involve collecting or assembling survey data on local prey availability and other natural and physical habitat features. Additionally, local natural hazards (e.g., sharks), human-caused hazards (potential human impacts on sea otters) (see section 5.2.1.1), and local socioeconomic effects (potential impacts by sea otters on human activities/values; see section 4.2) would need to be evaluated. Other considerations, such as furthering local ecosystem restoration goals, ensuring easier access for monitoring of released sea otters, or conducting a pilot study in a confined area could motivate the use of modified selection criteria (i.e., selection of one or more areas for reintroduction that were not among those having the highest local estimated carrying capacities) (see sections 6.3.1.2, 6.4.2).

Furthermore, the "research" cited by the Service in favor of benefits to a tourism economy based on viewing sea otters as compared to fisheries is silent on the practicalities of such transition, socially or economically.

If approved for funding, this proposed reintroduction research program would amount to an endless funding stream for sea otter advocates and researchers who support Southern sea otter translocations, while doing nothing for fisheries and communities economically and socially harmed by sea otter translocations.

Conclusion

The Southern sea otter has achieved an impressive recovery, thanks to decades of work by federal biologists, state agencies, conservationists, and the regulated community. Now, that work should be rewarded by acknowledging the species' recovery and delisting the species. Alternatively, it should be rewarded with a rule under Section 4(d) of the Endangered Species Act to provide appropriate regulatory relief and foster the goodwill needed for further recovery efforts.

DATED: April 24, 2026.

Damien M. Schiff, Cal. Bar. No. 235101
Pacific Legal Foundation
555 Capitol Mall, Suite 1290
Sacramento, CA 95814
Telephone: (916) 419-7111
DSchiff@pacificlegal.org

Respectfully submitted,

Nathan Hotes

Nathan Hotes, Va. Bar. No. 100337
Paige E. Gilliard, Cal. Bar. No. 330051
Pacific Legal Foundation
3100 Clarendon Blvd., Suite 1000
Arlington, VA 22203
(202) 888-6881
NHotes@pacificlegal.org
PGilliard@pacificlegal.org

Counsel for Petitioners California Sea Urchin Commission and Pacific Legal Foundation

Literature Cited

Alcock TM. 1992. Ecology Tankers and the Oil Pollution Act of 1990: A History of Efforts to Require Double Hulls on Oil Tankers. *Ecology Law Quarterly* 19:97-145. DOI: 10.15779/Z38W54J

American Petroleum Institute. 2015. Improvements To Offshore Safety by Industry and Government. Digital Media | DM2015-062 | 03.25 | PDF. https://www.api.org/~/media/Files/Oil-and-Natural-Gas/Exploration/Offshore/Improvements-to-Offshore-Safety-Report.pdf

Barbosa L, Johnson CK, Lambourn DM, Gibson AK, Haman KH, Huggins JL, Sweeny AR, Sundar N, Raverty SA, Grigg ME. 2015. A novel *Sarcocystis neurona* genotype XIII is associated with severe encephalitis in an unexpectedly broad range of marine mammals from the northeastern Pacific Ocean. I*nternational Journal for Parasitology,* 45(9-10). https://escholarship.org/uc/item/2nx76302

Battelle Pacific Northwest Laboratories. 1973. Environmental Assessment West Coast Deepwater Port Study. Report submitted to the to U.S. Army Engineer District, San Francisco, under contract DACW07-73-C—0063. 414pp. https://books.google.com/books?id=xgczAQAAMAAJ&pg=PR12&lpg=PR12&dq=Environmental+Assessment+West+Coast+Deepwater+Port+Study&source=bl&ots=zMBTJuXpfI&sig=ACfU3U1H2PAopYf5n26ndbu-q6lxRjU2Gw&hl=en&ppis=_c&sa=X&ved=2ahUKEwjwvL-R0I3nAhVZQ80KHVWcAWkQ6AEwAXoECAoQAQ#v=onepage&q=Environmental%20Assessment%20West%20Coast%20Deepwater%20Port%20Study&f=false

Bejarano AC, Mearns AJ. 2015. Improving environmental assessments by integrating Species Sensitivity Distributions into environmental modeling: Examples with two hypothetical oil spills. *Marine Pollution Bulletin* http://dx.doi.org/10.1016/j.marpolbul.2015.01.022; https://crrc.unh.edu/sites/crrc.unh.edu/files/bejarano_et_al._marine_pollution_2015.pdf

Bertranpetit E, Jombart T, Paradis E, Pena H, Dubey J, Su C, Mercier A, Devillard S, Ajzenberg D. 2017. Phylogeography of *Toxoplasma gondii* points to a South American origin. *Infectious Genetics and Evolution* 48:150-155. https://researchonline.lshtm.ac.uk/id/eprint/4650867/

Bonnet T et al., Genetic variance in fitness indicates rapid contemporary adaptive evolution in wild animals. *Science* **376**,1012-1016 (2022).DOI:10.1126/science.abk0853

Bowen L, Miles AK, Kolden CA, Saarinen JA, Bodkin JL, Murray M, Tinker T. 2015. Effects of wildfire on sea otter (*Enhydra lutris*) immune function. *Marine Mammal Science* 31: 191−210. https://onlinelibrary.wiley.com/doi/abs/10.1111/mms.12151; https://www.researchgate.net/publication/264200153_Effects_of_wildfire_on_sea_otter_Enhydra_lutris_gene_transcript_profiles

Boyce MS. Population Viability Analysis: Adaptive Management for Threatened and Endangered Species. 1993. Transactions of the 58th North American Wildlife and Natural Resources Conferences. Proceedings WWRC-93-19. Wildlife Management Institute.

Bull AS, Love MS. 2019. Worldwide oil and gas platform decommissioning: A review of practices and reefing options. *Ocean & Coastal Management* 168: 274-306. https://doi.org/10.1016/j.ocecoaman.2018.10.024

Bureau of Safety and Environmental Enforcement. 2016. Oil and Gas and Sulfur Operations in the Outer Continental Shelf—Blowout Preventer Systems and Well Control. Federal Register 81: 25888. https://www.govinfo.gov/content/pkg/FR-2019-05-15/pdf/2019-09362.pdf.

Bureau of Safety and Environmental Enforcement. 2019a. Oil and Gas and Sulfur Operations in the Outer Continental Shelf—Blowout Preventer Systems and Well Control Revisions. Federal Register 84(94): 21908-21985. https://www.regulations.gov/docket?D=BSEE-2018-0002

Bureau of Safety and Environmental Enforcement. 2019b. Final Environmental Assessment, May 2019, Rulemaking on Oil And Gas And Sulfur Operations In The Outer Continental Shelf - Blowout Preventer Systems And Well Control Revisions – 1014-AA39. https://www.regulations.gov/docket?D=BSEE-2018-0002

Burgess T, Tinker TM, Johnson C, MacCormick, H, Melli A, Conrad P. 2013. Epidemiological analysis of protozoal infections in sea otters at Big Sur and Monterey. In: Tinker MT, et al. (Eds.), Sea Otter Population Biology at Big Sur and Monterey California: Investigating the Consequences of Resource Abundance and Anthropogenic Stressors for Sea Otter Recovery. University of California, Santa Cruz, CA, pp. 196-234. https://www.fws.gov/ventura/docs/species/sso/Big%20Sur%20Monterey%20Sea%20Otter%20Study%20Draft%20Report.pdf

Burgess TL, Tinker TM, Miller MA, Bodkin JL, Murray, MJ, Saarinen JA, Nichol LM, Larson S, Conrad PA, Johnson CK. 2018. Defining the risk landscape in the context of pathogen pollution: *Toxoplasma gondii* in sea otters along the Pacific Rim. *Royal Society Open Science* 5: 171178. http://dx.doi.org/10.1098/rsos.171178

California Department of Fish and Wildlife. 2014. Status Review of White Shark (*Carcharodon carcharias*) in California. Report to the Fish and Game Commission. State of California, Natural Resources Agency, Department of Fish and Wildlife. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=80729&inline

California Department of Fish and Wildlife. 2019. Slight Dip in California Sea Otter Numbers, According to 2019 Survey Results. CDFW News. September 25, 2019. https://cdfgnews.wordpress.com/2019/09/25/slight-dip-in-california-sea-otter-numbers-according-to-2019-survey-results/

Carlson-Bremer D, Colegrove KM, Gulland FM, Conrad PA, Mazet JA, Johnson CK. 2015. Epidemiology and pathology of *Toxoplasma gondii* in free-ranging California sea lions (*Zalophus californianus*). *Journal of Wildlife Disease* 51(2):362-73. https://doi.org/10.7589/2014-08-205

Clarke KC, Hemphill JJ. 2002. The Santa Barbara Oil Spill, A Retrospective. Yearbook of the Association of Pacific Coast Geographers, Editor Darrick Danta, University of Hawai'i Press, vol. 64, pp. 157-162. Available at http://www.geog.ucsb.edu/~kclarke/Papers/SBOilSpill1969.pdf

Conrad PA, Miller MA, Kreuder C, James ER, Mazet J, Dabritz H, Jessup DA, Gulland F, Grigg ME. 2005. Transmission of *Toxoplasma*: clues from the study of sea otters as sentinels of *Toxoplasma gondii* flow into the marine environment. *International Journal for Parasitology* 35(11–12):1155-1168. https://doi.org/10.1016/j.ijpara.2005.07.002

Di Genova BM, Wilson SK, Dubey JP, Knoll LJ. 2019. **Intestinal delta-6-desaturase activity determines host range for Toxoplasma sexual reproduction.** *PLOS Biology* 17 (8): e3000364 DOI: https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3000364

Dubey, J.P., 2010. Toxoplasmosis of animals and humans, 2nd ed. CRC Press, Boca Raton, Florida. https://www.crcpress.com/Toxoplasmosis-of-Animals-and-Humans/Dubey/p/book/9781420092363

Dubey JP, Velmurugan GV, Rajendran C, Yabsley MJ, Thomas NJ, Beckmen KB, Sinnett D, Ruid D, Hart J, Fair PA, McFee WE, Shearn-Bochsler V, Kwok OCH, Ferreira LR, Choudhary S, Faria EB, Zhou H, Felix TA, Su C. 2011. Genetic characterization of *Toxoplasma gondii* in wildlife from North America revealed widespread and high prevalence of the fourth clonal type. *International Journal for Parasitology* 41(11): 1139-1147. https://doi.org/10.1016/j.ijpara.2011.06.005

https://webcache.googleusercontent.com/search?q=cache:GOTsKk6RfT0J:https://www.aphis.usda.gov/wildlife_damage/nwdp/Publications/11pubs/Dubey et al 2011.pdf+&cd=3&hl=en&ct=clnk&gl=us

Dubey JP, Howe DK, Furr M, et al. 2015. An update on *Sarcocystis neurona* infections in animals and equine protozoal myeloencephalitis (EPM). *Veternary Parasitol*ogy 209(1-2):1–42. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4461864/

Ehmen HG, Lüder CGK. 2019. Long-Term Impact of *Toxoplasma gondii* infection on human monocytes. *Frontiers in Cellular and Infection Microbiology* 9:235 https://doi.org/10.3389/fcimb.2019.00235

Flather CH, Hayward GD, Beissinger SR, Stephens PA. Minimum viable populations: is there a ‘magic number’ for conservation practitioners? Trends in Ecology & Evolution 2011; 26: 307-316.

Folland CK, Karl TR, Christy JR, Clarke RA, Gruza GV, Jouzel J, Mann ME, Oerlemans J, Salinger MJ, Wang S-W. 2001. Observed Climate Variability and Change. In: Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton JT, Ding Y, Griggs DJ, Noguer M, van der Linden PJ, Dai X, Maskell K, Johnson CA (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp. https://www.ipcc.ch/site/assets/uploads/2018/03/TAR-02.pdf

Franklin IR. 1980. Evolutionary Changes in Small Populations. In Conservation Biology: An Evolutionary-Ecological Perspective, 135–49. Sunderland, Massachusetts: Sinauer Associates.

Gagne RB, Tinker MT, Gustafson KD, et al. Measures of effective population size in sea otters reveal special considerations for wide-ranging species. *Evol Appl*. 2018; 11: 1779– 1790. https://doi.org/10.1111/eva.12642

Galal L, Hamidović A, Dard ML, Mercier M. 2019. Diversity of *Toxoplasma gondii* strains at the global level and its determinants. *Food and Waterborne Parasitology*, https://doi.org/10.1016/j.fawpar.2019.e00052

Godin, P., Nagykery, N., Sicher, N. *et al.* Gene therapy delivery of anti-Müllerian hormone in prepubertal female domestic cats induces long-term sterilization. *Nat Commun* **16**, 10747 (2025). https://doi.org/10.1038/s41467-025-65780-2

Hatfield BB, Yee JL, Kenner MC, Tomoleoni JA. 2019. California sea otter (*Enhydra lutris nereis*) census results, spring 2019: U.S. Geological Survey Data Series 1118, 12 p., https://doi.org/10.3133/ds1118

Hughes BB, Wasson K, Tinker MT, Williams SL, Carswell LP, Boyer KE, Beck MW, Eby R, Scoles R, Staedler M, Espinosa S, Hessing-Lewis M, Foster EU, M. Beheshti K, Grimes TM, Becker BH, Needles L, Tomoleoni JA, Rudebusch J, Hines E, Silliman BR. 2019. Species recovery and recolonization of past habitats: lessons for science and conservation from sea otters in estuaries. *PeerJ* 7:e8100 https://doi.org/10.7717/peerj.8100

Institute for Energy Research. 2010. Offshore oil drilling in shallow water: good safety record, less risky. Unpublished report. Available at: https://www.instituteforenergyresearch.org/fossil-fuels/gas-and-oil/offshore-oil-drilling-in-shallow-water-good-safety-record-less-risky/

Jeffers V, Tampaki Z, Kim K, Sullivan WJ. 2018. A latent ability to persist: differentiation in *Toxoplasma gondii*. *Cellular and Molecular Life Sciences* 75(13): 2355–2373. doi: 10.1007/s00018-018-2808-x https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5988958/

Jessup D, Miller M, Ames J, Harris M, Kreuder C, Conrad P, Mazet J. 2004. Southern sea otters as a sentinel for marine ecosystem health. *EcoHealth* 1: 239-245. https://link.springer.com/article/10.1007/s10393-004-0093-7; https://www.researchgate.net/publication/225476799_Southern_Sea_Otter_as_a_Sentinel_of_Marine_Ecosystem_Health

Jiang T, Shwab EK, Martin RM, Gerhold RW, Rosenthal BM, Dubey JP, Su C. 2018. A partition of *Toxoplasma gondii* genotypes across spatial gradients and among host species, and decreased parasite diversity towards areas of human settlement in North America. *International Journal of Parasitology* 48:611–619. https://doi.org/10.1016/j.ijpara.2018.01.008

Johnson CK, Tinker MT, Estes JA, Conrad PA, Staedler M, Miller MA, Jessup DA, Mazet JAK. 2009. Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal system. *Proceedings of the National Academies of Science U.S.A.* 106: 2242-2247. https://www.pnas.org/content/early/2009/01/21/0806449106

Khan A, Ajzenberg, D, Mercier A, Demar M, Simon S, Dardé ML, Wang Q, Verma SK, Rosenthal BM, Dubey JP, Sibley LD. 2014. Geographic separation of domestic and wild strains of *Toxoplasma gondii* in French Guiana correlates with a monomorphic version of chromosome1a. *PLoS Neglected Tropical Diseases* 8, e3182. https://doi.org/10.1371/journal.pntd.0003182

Krusor C, Smith WA, Tinker MT, Silver M, Conrad PA, Shapiro K. 2015. Concentration and retention of *Toxoplasma gondii* oocysts by marine snails demonstrate a novel mechanism for transmission of terrestrial zoonotic pathogens in coastal ecosystems. *Environmental Microbiology*. 17(11):4527-37. https://doi.org/10.1111/1462-2920.12927; https://www.researchgate.net/publication/277600720_Concentration_and_retention_of_Toxoplasma_gondii_oocysts_by_marine_snails_demonstrate_a_novel_mechanism_for_transmission_of_terrestrial_zoonotic_pathogens_in_coastal_ecosystems

Lafferty KD. 2015. Sea otter health: Challenging a pet hypothesis. *International Journal for Parasitology: Parasites and Wildlife* 4(3): 291-294. http://dx.doi.org/10.1016/j.ijppaw.2015.05.005

Lafferty KD. 2017. Marine infectious disease ecology. *Annual Review of Ecology, Evolution, and Systematics* 48: 473–96. https://doi.org/10.1146/annurev-ecolsys-121415-032147 http://parasitology.msi.ucsb.edu/sites/parasitology.msi.ucsb.edu/files/docs/publications/Lafferty2017annurev-ecolsys.pdf

Laidre KL, Jameson RJ, DeMaster DP. 2001. An estimation of carrying capacity for sea otters along the California coast. *Marine Mammal Science* 17:294–309. https://doi.org/10.1111/j.1748-7692.2001.tb01272.x

Lande R. 1976. "The Maintenance of Genetic Variability by Mutation in a Polygenic Character with Linked Loci." Genetics Research 26: 221–35.

Lehmann T, Marcet PL, Graham DH, Dahl ER, Dubey JP. 2006. Globalization and the population structure of *Toxoplasma gondii*. *Proceedings of the National Academy of Sciences USA* 103, 11423–11428. https://www.pnas.org/content/103/30/11423

Lenart P, Bienertová-Vašků J, Berec L. Learning mitigates genetic drift. *Sci Rep* **12**, 20403 (2022). https://doi.org/10.1038/s41598-022-24748-8

Li YC, Korol AB, Fahima T, Beiles A, Nevo E. Microsatellites: genomic distribution, putative functions and mutational mechanisms: a review. *Mol Ecol.* 2002; **11**(12):2453–2465. doi: 10.1046/j.1365-294X.2002.01643.x.

Massie GN, Ware MW, Villegas EN, Black MW. 2010. Uptake and transmission of *Toxoplasma gondii* oocysts by migratory, filter-feeding fish. *Veterinary Parasitology* 169(3-4): 296-303. https://www.ncbi.nlm.nih.gov/pubmed/20097009.

Miller MA, Gardner IA, Kreuder C, Paradies DM, Worcester KR, et al. 2002. Coastal freshwater runoff is a risk factor for *Toxoplasma gondii* infection of southern sea otters (En*hydra lutris nereis*). *International Journal for Parasitology* 32:997–1006. https://doi.org/10.1016/S0020-7519(02)00069-3

Miller MA, Grigg ME, Kreuder C, James ER, Melli AC, Crosbie PR, Jessup DA, Boothroyd JC, Brownstein D, Conrad PA. 2004. An unusual genotype of *Toxoplasma gondii* is common in California sea otters (*Enhydra lutris nereis*) and is a cause of mortality. *International Journal of Parasitology* 34, 275–284. https://doi.org/10.1016/j.ijpara.2003.12.008

Miller MA, Miller WA, Conrad PA, James ER, Melli AC, Leutenegger CM, Dabritz HA, Packham AE, Paradies D, Harris M, Ames J, Jessup DA, Worcester K, Grigg ME. 2008. Type X *Toxoplasma gondii* in a wild mussel and terrestrial carnivores from coastal California: new linkages between terrestrial mammals, runoff and toxoplasmosis of sea otters. *International Journal of Parasitology* 38(11):1319-28. https://doi.org/10.1016/j.ijpara.2008.02.005; http://www.otterproject.org/wp-content/uploads/2012/05/Miller_etal_2008_Type_X_Toxoplasma_gondii_in_wild_mussel_and_terrestrial_carnivores.pdf

Miller MA, Conrad PA, Harris M, Hatfield B, Langlois G, Jessup DA, Magargal SL, Packhamb AE, Toy-Choutkaa S, Melli AC, Murray MA, Gullandg FM, Grigg ME. 2010. A protozoal-associated epizootic impacting marine wildlife: Mass-mortality of southern sea otters (*Enhydra lutris nereis*) due to *Sarcocystis neurona* infection. https://www.marinemammalcenter.org/assets/pdfs/vetsci-stranding/scientific-contributions/2010/miller-2010-sarcocystis-1.pdf

Miller MA, Dodd E, Berberich E, Batac F, Henkel L, et al. 2013. Preliminary findings from necropsy of tagged sea otters from the Monterey–Big Sur Study. In Sea Otter Population Biology at Big Sur and Monterey California: Investigating the Consequences of Resource Abundance and Anthropogenic Stressors for Sea Otter Recovery, ed. MT Tinker, pp. 207–35. DRAFT Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service, Univ. Calif., Santa Cruz, CA http://www.fws.gov/ventura/docs/species/sso/Big Sur Monterey Sea Otter Study Draft Report.pdf

Muehlenbachs L, Cohen M, Gerarden T. 2013. The impact of water depth on safety and environmental performance in offshore oil and gas production. *Energy Policy*. 55. 699–705. http://www.sciencedirect.com/science/article/pii/S030142151201141X

National Research Council. 2005. *Oil Spill Dispersants: Efficacy and Effects*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11283.

National Research Council 2012. Macondo Well Deepwater Horizon Blowout: Lessons for Improving Offshore Drilling Safety. Washington, DC: The National Academies Press. https://doi.org/10.17226/13273.

New York Times. 2003. Outdoor Cats Blamed in Otter Deaths. Published 03/18/2003. https://www.nytimes.com/2003/03/18/science/outdoor-cats-blamed-in-otter-deaths.html?module=inlineIn 2000

New York Times. 2019. What's Killing California's Sea Otters? House Cats. Published 8/28/2019. https://www.nytimes.com/2019/08/28/science/california-sea-otters-cats.html

O'Byrne A, Lambourn D, Rejmanek D, Dalley B, Haman K, Vanwormer E, Packham A, Conrad P, Shapiro K. 2019. Molecular epidemiology of *Sarcocystis neurona* from land-to-sea: Detection and molecular characterization in opossums and marine mammals from western Washington. Unpublished research poster. Available at https://www.vetmed.ucdavis.edu/sites/g/files/dgvnsk491/files/inline-files/OByrne.pdf

Pinkston FWM, Flemings PB. 2019. Overpressure at the Macondo Well and its impact on the Deepwater Horizon blowout. *Scientific Reports* 9, 7047. https://www.nature.com/articles/s41598-019-42496-0.pdf

Platt, J.R. 1964. Strong Inference: Certain Systematic Methods of Scientific Thinking May Produce Much More Rapid Progress than Others. *Science* 146(3642): 347–353. https://science.sciencemag.org/content/146/3642/347.long

Popper, K.R. 1962. Science: Conjectures and Refutations. In *Conjectures and Refutations: The Growth of Scientific Knowledge*. New York: Basic Books. https://www.academia.edu/38681885/Karl_Popper_Conjectures_and_Refutations

Rejmanek D, Vanwormer E, Miller MA, Mazet JAK, Nichelason AE, Melli AC, Packham AE, Jessup DA, Conrad PA. 2009. Prevalence and risk factors associated with *Sarcocystis neurona* infections in opossums (*Didelphis virginiana*) from central California. *Veterinary Parasitology* 166: 8–14. https://www.sciencedirect.com/science/article/abs/pii/S0304401709004993?via%3Dihub

Shapiro K, Krusor C, Mazzillo FF, Conrad PA, Largier JL, Mazet JA, Silver MW. 2014. Aquatic polymers can drive pathogen transmission in coastal ecosystems. *Proceedings of the Royal Society B* 281(1795). pii: 20141287. https://royalsocietypublishing.org/doi/10.1098/rspb.2014.1287

Shapiro K, Bahia-Oliveira L, Dixon B, Dumètre A, de Wit LA, VanWormer E, Villena I. 2019a. Environmental transmission of *Toxoplasma gondii*: Oocysts in water, soil and food. *Food and Waterborne Parasitology*, *15*, [e00049]. https://doi.org/10.1016/j.fawpar.2019.e00049; https://reader.elsevier.com/reader/sd/pii/S2405676618300428?token=DD3D1CB2D863CF08C8E6E856FDD0934DC633930BB3D135436D1F86B1ECEDF6157C2420037428A466CE50E5FA43294BC2

Shapiro K, VanWormer E, Packham A, Dodd E, Conrad PA, Miller M. 2019b. Type X strains of *Toxoplasma gondii* are virulent for southern sea otters (*Enhydra lutris nereis*) and present in felids from nearby watersheds. *Proceedings of the Royal Society B* 286 : 20191334. http://dx.doi.org/10.1098/rspb.2019.1334

Shwab EK, Zhu X-Q, Majumdar D, Pena HFJ , Gennari SM, Dubey JP, Su C. 2014. Geographical patterns of *Toxoplasma gondii* genetic diversity revealed by multilocus PCR-RFLP genotyping. *Parasitology* 141: 453–461. https://doi.org/10.1017/S0031182013001844; https://www.researchgate.net/publication/259985070_Geographical_patterns_of_Toxoplasma_gondii_genetic_diversity_revealed_by_multilocus_PCR-RFLP_genotyping

Shwab EK, Saraf P, Zhu X-Q, Zhou D-H, McFerrin BM, Ajzenberg D, Schares G, Hammond-Aryee K, van Helden P, Higgins SA, Gerhold RW, Rosenthal BM, Zhao X, Dubey JP, Su C. 2018. Human impact on the diversity and virulence of the ubiquitous zoonotic parasite *Toxoplasma gondii*. *Proceedings of the National Academy of Sciences* 115 (29) E6956-E6963; https://www.pnas.org/content/115/29/E6956

Smith NF. 2007. Associations between shorebird abundance and parasites in the sand crab, *Emerita analoga*, along the California coast. *Journal of Parasitology* 93:265–73. https://www.journalofparasitology.org/doi/abs/10.1645/GE-1002R.1; https://www.researchgate.net/publication/6297628_Associations_between_shorebird_abundance_and_parasites_in_the_sand_crab_Emerita_analoga_along_the_California_coast

Smithsonian Magazine. 2019. Parasite Spread by House Cats Is Killing California's Sea Otters. Published 08/29/2019. https://www.smithsonianmag.com/smart-news/parasite-spread-house-cats-killing-californias-sea-otters-180973014/ - C0sB7k05BrZAFFLu.99

Spyrou AG 2011. From T-2 to Supertanker: Development of the Oil Tanker, 1940 - 2000, Revised. iUniverse ISBN: 9781462002351, 1462002358.

Stenman C. 2005. The Development of the MARPOL and EU Regulations to Phase out Single Hulled Oil Tankers. Masters Thesis, School of Economics and Commercial Law, Göteborg University, Sweden. https://gupea.ub.gu.se/handle/2077/1941

Stocker WA, Olenick L, Maskey S *et al.* Gene therapy with feline anti-Müllerian hormone analogs disrupts folliculogenesis and induces pregnancy loss in female domestic cats. *Nat Commun* **16**, 1668 (2025). https://doi.org/10.1038/s41467-025-56924-5

Thometz NM, Staedler MM, Tomoleoni JA, Bodkin JL, Bentall GB, Tinker MT. 2016. Trade-offs between energy maximization and parental care in a central place forager, the sea otter. *Behavioral Ecology* 27(5): 1552–1566. https://academic.oup.com/beheco/article/27/5/1552/1744884
Tinker MT, Bentall G, Estes JA 2008. Food limitation leads to behavioral diversification and dietary specialization in sea otters. *Proceedings of the National Academy of Sciences of the USA* 105:560–565. https://doi.org/10.1073/pnas.0709263105

Tinker MT. 2013. Tinker MT (Ed.), Sea Otter Population Biology at Big Sur and Monterey California: Investigating the Consequences of Resource Abundance and Anthropogenic Stressors for Sea Otter Recovery, University of California, Santa Cruz, CA. DRAFT Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service. http://www.fws.gov/ventura/docs/species/sso/Big Sur Monterey Sea Otter Study Draft Report.pdf

Tinker MT, Hatfield BB**,** Harris MD, Ames JA. 2016. Dramatic increase in sea otter mortality from white sharks in California. *Marine Mammal Science* 32(1): 309-326. https://beachwatch.farallones.org/wp-content/uploads/2016/03/TINKER-2015-DRAMATIC-INCREASE-IN-SEA-OTTER-MORTALITY-FROM-WHITE-SHARKS-IN-CA.pdf

Tinker MT, Tomoleoni J, LaRoche N, Bowen L, Miles AK, Murray M, Staedler M, Randell Z. 2017. Southern sea otter range expansion and habitat use in the Santa Barbara Channel, California: U.S. Geological Survey Open-File Report 2017–1001 (OCS Study BOEM 2017-002), 76 p., http://doi.org/10.3133/ofr20171001.

Tinker MT, Tomoleoni JA, Weitzman BP, Staedler M, Jessup D, Murray MJ, Miller M, Burgess T, Bowen L, Miles AK, Thometz N, Tarjan L, Golson E, Batac F, Dodd E, Berberich E, Kunz J, Bentall G, Fujii J, Nicholson T, Newsome S, Melli A, LaRoche N, MacCormick H, Johnson A, Henkel L, Kreuder-Johnson C, Conrad P. 2019. Southern sea otter (*Enhydra lutris nereis*) population biology at Big Sur and Monterey, California—Investigating the consequences of resource abundance and anthropogenic stressors for sea otter recovery: U.S. Geological Survey Open-File Report 2019 -1022, 225 p., https://doi.org/10.3133/ofr20191022.

Tinker MT, Carswell LP, Tomoleoni JA, Hatfield BB, Harris MD, Miller MA, Moriarty ME, Johnson, CK, Young C, Henkel LA, Staedler MM, Miles AK, Yee, JL. 2021a. An integrated population model for southern sea otters: U.S. Geological Survey Open-File Report 2021–1076, 50 p., https://doi.org/10.3133/ofr20211076.

Tinker MT, Yee JL, Laidre KL, Hatfield BB, Harris MD, Tomoleoni JA, Bell TW, Saarman E, Carswell LP, Miles AK, 2021b. Habitat features predict carrying capacity of a recovering marine carnivore: The Journal of Wildlife Management, v. 85, no. 2, p. 303–323, https://doi.org/10.1002/jwmg.21985.

Tinker MT. 2021. Incorporating Oil Spill Simulations into the Southern Sea Otter Integrated Population Model. Prepared by M. Tim Tinker, Nhydra Ecological Research and Conservation Metrics for U.S. Fish and Wildlife Service. March 2021. Appendix to USFWS 2023. Species Status Assessment for the Southern Sea Otter (Enhydra lutris nereis). U.S. Fish and Wildlife Service, Region 8. Sacramento, CA. 101 pp. + Appendix.

Torgerson PR, Mastroiacovo P. 2013. The global burden of congenital toxoplasmosis: a systematic review. *Bulletin of the World Health Organization* 91:501-508. http://dx.doi.org/10.2471/BLT.12.111732

U.S. Chemical Safety and Hazard Investigation Board. 2016. Drilling rig explosion and fire at the Macondo Well. Investigation Report No. 2010-10-I-Os 04/12/2016. https://www.csb.gov/macondo-blowout-and-explosion/

U.S. Coast Guard. 2000. Traffic Separation Scheme: In the Approaches to Los Angeles-Long Beach, California *Federal Register* 65(173): 53911-53914.

U.S. Coast Guard. 2011. Pollution Incidents In and Around U.S. Waters A Spill/Release Compendium: 1969 - 2011. Washington, D.C. Available at https://homeport.uscg.mil/Lists/Content/DispForm.aspx?ID=226&Source=/Lists/Content/DispForm.aspx?ID=226

U.S. Fish and Wildlife Service. 1977. Determination that the Southern Sea Otter is a Threatened Species. *Federal Register* 42(10): 2965-2968.

U.S. Fish and Wildlife Service. 2012. Final Supplemental Environmental Impact Statement on the Translocation of Southern Sea Otters. Ventura Fish and Wildlife Office, Ventura, California. 348 pp. + front matter and appendices.

U.S. Fish and Wildlife Service. 2015. Southern Sea Otter (*Enhydra lutris nereis*) 5-Year Review: Summary and Evaluation. September 15, 2015. U.S. Fish and Wildlife Service, Ventura, California.

U.S. Fish and Wildlife Service. 2017. Southern Sea Otter (*Enhydra lutris nereis*). Stock Assessment. U.S. Fish and Wildlife Service, Ventura, California.

U.S. Fish and Wildlife Service. 2023. Species Status Assessment for the Southern Sea Otter (*Enhydra lutris nereis*). U.S. Fish and Wildlife Service, Region 8. Sacramento, CA. 101 pp. + Appendix.

Wang J., Santiago E, Caballero A. Prediction and estimation of effective population size. *Heredity* **117**, 193–206 (2016). https://doi.org/10.1038/hdy.2016.43

Vansandt, L.M., Meinsohn, MC., Godin, P. *et al.* Durable contraception in the female domestic cat using viral-vectored delivery of a feline anti-Müllerian hormone transgene. *Nat Commun* **14**, 3140 (2023). https://doi.org/10.1038/s41467-023-38721-0

VanWormer E, Conrad P, Miller M, Melli A, Carpenter T, Mazet JK. 2013 *Toxoplasma gondii*, Source to sea: higher contribution of domestic felids to terrestrial parasite loading despite lower infection prevalence. *EcoHealth* 10, 277–289. https://link.springer.com/article/10.1007/s10393-013-0859-x; https://www.researchgate.net/publication/256764525_Toxoplasma_gondii_Source_to_Sea_Higher_Contribution_of_Domestic_Felids_to_Terrestrial_Parasite_Loading_Despite_Lower_Infection_Prevalence

VanWormer E, Miller MA, Conrad PA, Grigg ME, Rejmanek D, Carpenter TE, Mazet JAK. 2014. Using molecular epidemiology to track *Toxoplasma gondii* from terrestrial carnivores to marine hosts: implications for public health and conservation. *PLoS Neglected Tropical Diseases* 8(5): e2852. https://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0002852

Wheeling K, Ufberg M. 2017. 'The Ocean Is Boiling': The Complete Oral History of the 1969 Santa Barbara Oil Spill. *Pacific Standard*. Published: Apr 18, 2017, Updated: Nov 7, 2018. Available at https://psmag.com/news/the-ocean-is-boiling-the-complete-oral-history-of-the-1969-santa-barbara-oil-spill

Zhu S, Camp L, Patel A, VanWormer E, Shapiro K. 2023. High prevalence and diversity of *Toxoplasma gondii* DNA in feral cat feces from coastal California. PLoS Negl Trop Dis 17(12): e0011829. https://doi.org/10.1371/journal.pntd.0011829